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Distributions of Eagles and a Survey for and Habitat Characteristics of Communal Roosts of Bald Eagles (*Haliaeetus leucocephalus*) Wintering in Northeastern Wyoming

Prepared for the

Bureau of Land Management

and the

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by

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Introduction

Major concentrations of bald eagles occur in northeastern Wyoming during winter. These eagles typically use communal roosts as night roosts and diurnal loafing sites. Many locations of roosts are well documented and it is likely that other communal roosts occur because concentrations of bald eagles have been observed considerable distances from known roost sites near habitat that appear favorable for roosts.

Northeastern Wyoming is also an area of interest because of ongoing energy development and known extensive reserves of coal and petroleum. Since human activity affects eagle distribution and behavior adversely (Stalmaster and Newman 1978), energy developments may disrupt traditional roost sites. This would violate guidelines described by the Endangered Species Act of 1973 and the Bald Eagle Act of 1978. For resource managers to assess environmental impacts and to describe mitigation procedures, it is necessary to know locations of roosts. Knowing physiographic and vegetative characteristics of roosts would also be helpful since managers may be able to identify sites of roosts without extensive monitoring of an area.

There are at least 15 documented night communal roost sites of bald eagles in northeastern Wyoming (Jenkins et al. 1981, Postivit 1984, Oakleaf pers. comm. 1984, Bagdonas et al. 1985, Dahlem pers. comm. 1985). Several of these roosts are documented relative to location and that they are used perennially. Other locations of potential roost sites have been identified by observation of numbers of eagles, however, no ground truthing or regular observations were made to determine the area as a roost. Concentrations of eagles have been noted elsewhere but no roost sites have been reported.

Locations of roosts coincide with an available food source. In South Dakota, wintering bald eagles perched as close as possible to feeding areas (Steenoff et al. 1982) and in the Klamath Basin in Oregon and California, eagles roosted in the closest site to feeding areas that met certain vegetative requirements (Keister and Anthony 1983). Roosts also provide protection from severe weather. Communal night roosts were used more often during days of winds greater than 17 km/hr (Steenoff et al. 1980) or during periods of inclement weather (Edwards 1969).

Previous work on characteristics of forest stands of roosts showed that eagles select the largest, more open structured conifers for roosting (Keister and Anthony 1983). Bald eagles roosting along riparian areas of cottonwoods (Populus deltiodes) selected the largest cottonwoods bordering the river (Steenoff et al. 1980). Little information is available on the characteristics of roosts in Wyoming.

This project was developed to describe distributions of eagles in northeastern Wyoming, locate additional communal night roosts, and to describe characteristics of forest stands in roosts of conifers. The objectives of this project were:

1. Locate roosts using aerial surveys and consolidate data on other locations of roosts using reported sightings.
2. Describe distribution of eagles relative to major food sources.
3. Determine physiographic features of roosts.
4. Determine characteristics of forest stands of roosts.

Study Area

Surveys were conducted in Sheridan, Campbell, Johnson, Natrona, Converse, Platte, Goshen, Niobrara, Weston, and Crook Counties. The major land use in these counties is cattle ranching although sheep ranching is

common in the southwestern portion of the study area particularly in Converse and Natrona Counties. Farming occurs in all counties but is widespread.

Major types of vegetation in the area include conifer forests, mixed shrubland, and great plains grassland (Lanka et al. 1982). Topography consists of extensive plains with hills interspersed with, and bordered by, open low mountains (Bailey 1980). Several rivers that are bordered by cottonwoods flow through the area. Eagles typically roost in cottonwoods along streams and in uplands with conifers adjacent to plains.

Methods

Locations of roosts were determined by consolidating sightings of eagles and potential roosts as determined by the U.S. Bureau of Land Management, U.S. Forest Service, Wyoming Game and Fish Department, and the U.S. Fish and Wildlife Service. One-hundred hours of flying were also used to locate roosts. Flying began as early in the morning as possible and most flights ended by 1300 hours. Areas were flown between 60-100 m high and at 80-110 km/hr. Potential roosts and eagles observed were marked on 30 x 60 minute quadrangle maps. Roosts were defined as an area where eagles were observed more than once, where considerable white-wash was found on trees and numbers of castings found, or where previous surveys by agencies identified the area as a roost. Potential roosts were defined as those areas where eagles had been observed by previous surveys or where we observed numbers of eagles but no subsequent observations identified the area as a roost.

All roosts and some potential roosts were marked on 7.5 minute quadrangle maps (Appendix A, and B, respectively). The 2 known nests of

bald eagles in Sheridan County were also marked on maps (Appendix C). Legal locations of heronries were also recorded (Appendix D).

Foods of eagles were determined by collecting castings beneath roosts and recording percent occurrence of sheep (*Ovis aries*), pronghorn (*Antelocapra americana*), and other food items in each casting examined. Distribution relative to these 2 major food sources was determined by comparing distances from eagles observed and random points to pronghorn wintering areas and the larger sheep ranches. Locations of eagles observed, and upland and riverine areas flown were marked on 1:500,000 scale maps (Appendix E). Systematically located random points were marked on these maps within areas surveyed. Random points in upland areas were determined by overlaying a grid map with a randomly selected orientation for each county and marking 1 point per 10 km^2. Along streams, random points were marked using a randomly chosen starting point along each stream searched and marking 1 point each 10 km.

Maps at 1:500,000 scale of pronghorn winter ranges and populations of the herd units were provided by the Wyoming Game and Fish Department (Appendix F). Each population was classified using an average population estimate between 1979 and 1983 and classified as high (>3000) or low (<3000). Personnel in the Soil Conservation Service and the Agriculture Soil Conservation Service offices in each county mapped on 30 x 60 minute quadrangle maps locations of sheep ranches and their property that were known to own at least 2,000 sheep. Ranches owning more than 2,000 sheep were selected because many ranchers in the area own sheep but these are primarily farm flocks that are fed during winter and are maintained close to the ranch buildings while most sheep ranchers with large herds range their sheep during winter without supplemental feeding. It was these

larger sheep ranches that we expected eagles to be associated with. These ranches were subsequently marked on 1:500,000 scale maps (Appendix F). Minimum distances between sheep ranches and pronghorn winter ranges to observations of eagles were measured to the nearest km and classified as 1 (<1 km), 2 (> 1 km and < 5 km), or 3 (>5 km). Those eagles observed along the North Platte River were excluded from this analyses since numbers of waterfowl were observed and may have made up a large portion of their diet.

Weather data between October and March for the past 5 winters was provided by the National Atmospheric and Oceanic Administration collected at the Casper and Sheridan airports. Average numbers of days of wind averaging $\geq$ 17 mph and direction of wind were determined for each site for all years.

Physiographic features of roosts were determined for upland sites using 7.5 minute topographic maps. Twenty-three roosts were compared to 92 random sites. We randomly selected 4 points within a 6 km radius of each roost and measured the nearest valley that had a slope of at least 15%. Variables measured at random and roost sites included (1) the length of the ridge in the valley where the sampling point was located, up to 1 km, (2) distance to the opposite ridge at the widest point, up to 1 km, (3) height of both ridges, (4) slope of both sides of the valley which were classed between 15% and 50% at 5% intervals, (5) aspect of both sides of the valley classified into 16° arcs, (6) orientation of the mouth of the valley, (7) center of the direction of view from midpoint of the roost or nonroost slope (Harmata 1984), (8) angle of view from the same point (Harmata 1984), and (9) distances in km to the nearest occupied dwelling, oil or gas well, improved road, unimproved road, and a riparian zone with cottonwoods. Most

data were collected from 7.5 minute quadrangle maps, however, some distances to energy development and dwellings were supplemented by field notes. Comparisons between variables measured in roosts and random sites were done using a chi-square goodness of fit test.

Trees in 20 roosts were sampled to describe characteristics of forest stands of roosts. Four roosts were located near Casper, 9 in the Rochelle Hills area, 1 on Pine Ridge on the headwaters of the North Fork of the Cheyenne River, 2 in the Miller Hills, 2 in the Broken Horn area of the southern end of the Big Horn Mountains, and 2 on Pine Mountain.

Characteristics of forest stands in roosts greater than 1 ha were determined by randomly selecting .04 ha plots for each .40 ha of roost measured and measuring all trees in plots. These larger roosts were systematically searched for roost trees, and all roost trees found were measured. In roosts less than 1 ha, all trees were measured. The total area of the roost was measured using a 100 m tape. Variables measured on trees in each roost included species of tree, dbh size class of tree were determined using a dbh tape and classed as 1 (<7 cm), 2 (>7 and < 14 cm), 3 (>14 cm and <21 cm), 4 (>21 and < 28 cm), 5 (> 28 and< 34 cm), 6 (> 34 and < 41 cm), 7 (>41 and < 49 cm), 8 (>49 and < 56 cm), or 9 (>56 cm) height of trees were measured using a Haga and classed as 1 (< 5 m), 2 (> 5 and < 10 m), 3 (>10 and <15 m), 4 (>15 and < 20 m), 5 (> 20 and < 25 m), 6 (> 25 and <30 m), 7 (>30 and <35 m), or 8 (>35 m), structure classes of trees followed Keen (1943) (Figure 1), if the tree was alive or dead, roost or nonroost tree, presence or absence of engraver beetles (Scolytidae), and the position of the trees on the slope was recorded as (0)> 10% of the crown of the tree being above the horizon or (1)> 90% of the tree below the horizon. Differences between the forest stand of roosts and roost trees

Figure 1. Characteristics used to classify trees in bald eagle communal roosts in northeastern Wyoming. Adapted from Keen (1943).

among all roosts were determined using a sign and Wilcoxon tests using the most conservative statistic of the tests.

Forest stand characteristics of 16 roost sites were compared to forests in 57 nonroost sites that were systematically selected from 7.5 minute quadrangle maps and ground searches. Roosts were selected based on accessibility and included 11 roosts in the Rochelle Hills area, 2 on Pine Mountain, 2 on Big Sulfur Springs, and 1 on the headwaters of the North Fork of the Cheyenne River.

We selected nonroost sites with slope and aspects similar to those of roosts. One site was selected in each of 4 directional quadrants of the roost that had a slope $> 30\%$, an exposure of $< 90°$, and at least 3 trees larger than 28 cm dbh. Some quadrants from roosts did not have suitable slope exposure or lacked trees. At least 3 nonroost plots were selected for all roosts. Plots were up to 1 ha in size and all trees larger than 28 cm dbh were measured. Variables measured on trees in nonroost slopes were the same as those measured on trees in roosts. Data were averaged among plots and compared to the roost from where the nonroost points were selected. Differences between roost and nonroost sites were determined using a sign and Wilcoxon test.

Results

Survey for Roosts

We identified 9 roosts during aerial surveys in upland areas (Appendix A, Table 1). These included the roosts Tisdale Mountain, Linch, Big Sulfur Springs West, Pine Ridge B near Midwest, Pine Ridge north of Kaycee, Cheyenne River, Little Deer Creek West, and Seaman Hills (Appendix A). All but the Pine Ridge Roost north of Kaycee were ground-truthed. Eight additional roosts were found during ground searches and included the roosts

Little Deer Creek East, Pine Ridge near Midwest (A and C), Big Sulfur Springs East, Keyton Creek North, Miller Hills B, and Keeline Roosts C and D. Although no birds were observed in these roosts during aerial surveys, roosts were easily recognized by the white-wash on trees and castings were found beneath trees. Occasionally, we observed birds in roosts while doing field work.

Along streams, we recorded 7 additional roosts (Appendix A, Table 1). Most of these were along the Powder River and Crazy Woman Creek in Johnson County. Four new roost sites were found along the Powder River, and other roosts located included the Crazy Woman Creek West Roost, the Wallow's Creek Roost, the Trabing Creek Roost, the Cole Creek Roost on the North Platte River near Casper, and Stinking Creek Roost south of Casper. Only the Wallow's Creek roost, Powder River North roost, and the Stinking Creek Roost were ground-truthed. Many castings were found beneath trees at the Wallow's Creek and Powder River North roosts. The Stinking Creek roost had white-wash on the trees and fresh snow likely covered castings.

Four sites were classified as potential roosts that deserve particular attention. The potential roost site on North Pumpkin Butte appeared to be a well used roost from the air having at least 1 large snag covered with white-wash. A second area of interest is the Teapot Dome area. Many eagles were observed in this area during surveys and a likely roost site was identified. The potential roost along Old Woman Creek seemed to be characteristic of other roosts found in that white-wash and wool was observed on branches of trees from the aircraft. However, only 2 castings were found beneath trees, but this may have been because cattle wintered among the roost trees and may have trampled castings. Finally, a likely site was found in spring 1985 by A. Beske north of the Keeline Roosts near

Black Thunder Creek (R. Kiewit pers. comm. 1985). These areas need additional field observations to determine use by eagles.

We were able to compare our data along the Powder River, Crazy Woman Creek, and Clear Creek to those of Jenkins et al. (1981). Comparisons suggest that there has been shifting of roosts over the years. Jenkins et al. (1981) reported a roost at the headwaters of the Middle Fork of the Powder River while we consistently observed only 2-3 eagles in this area as did the Wyoming Game and Fish Department (B. Luce pers. comm. 1985). Subsequent ground searches showed no signs of a specific roost tree and only 2 castings were found. We found 5 roosts that were previously not reported along the Powder River and Crazy Woman Creek and 3 of these new roosts were near those previously reported. One roost was on the Powder River near Kaycee, 1 was the Crazy Woman Roost West Roost, and the other was the Powder River Jones North Roost. The Culp Flat roost and Bowman Flat roost were also not previously documented. We also observed eagles in the previously documented Clear Creek Roost, Crazy Woman East Roost and the Powder River Jones South Roost (Table 1).

The Cole Creek Roost was unique since it was the only concentration of eagles along the North Platte River upstream from the Dave Johnson Power Plant. It is also likely that this roost is a staging area for birds traveling between feeding areas and nearby upland roosts. On 21 and 22 February, we observed 1 immature bald eagle and 3 subadult bald eagles, respectively, leave the Cole Creek roost and fly in the direction of the Box Elder Creek and Little Deer Creek Roosts.

Downstream from the Glenrock Power Plant, the North Platte River was not frozen and we observed many eagles along the river to Douglas, Wyoming. Numbers of waterfowl were also observed along the river. Since bald eagles

Table 1. Eagles observed in roosts during aerial surveys during December 1984, and January and February 1985.

Roost	Date	Adult Bald	Immature Bald	Golden Eagle
Antelope Creek	25 Jan	2		
Belle Fourche	24 Jan	4		
Big Sulfur Springs West	1 Feb	9	6	
Cheyenne River	18 Dec	2		
	31 Jan	2		
Keeline (A)	25 Jan	4	5	
Keeline (B)	25 Jan	6	8	
Keyton Creek South	25 Jan	4	5	
Baerthel Canyon	16 Dec	3	1	
School Creek	25 Jan		1	1
Linch	16 Jan	4	2	
	1 Feb	2	3	
Tisdale Mountain	16 Jan	1		
Jackson Canyon	2 Feb	2	1	1
Little Red Creek	2 Feb			1
Deer Creek*'**	16 Jan	5		
Little Deer Creek	16 Jan			1
	31 Jan	6	8	
Teapot Dome *'**	10 Jan	2		1

Pine Ridge (B)	17 Dec	4	8	
Pine Ridge (Kaycee)*	15 Jan	2	7	
	16 Jan	2	4	4
	5 Feb	3	3	
Pumpkin Buttes*'**	5 Feb	3	4	
Seaman Hills	16 Jan	3		1
	3 Feb	2	1	
Roosts in Riparian Areas				
Coal Creek*	16 Jan	7	5	
	3 Feb	12	14	
	4 Feb	5	2	
Stinking Creek	2 Feb	5	2	1
	3 Feb	4	5	2
Powder River/Kaycee*	1 Feb	4	6	
	5 Feb	5	7	
Powder River Bowman Flat*	14 Jan	9	3	1
	6 Feb	2		
Powder River Culp Flat*	14 Jan		2	
	6 Feb	6	2	
Crazy Woman West*	12 Jan	4	2	
	15 Jan	6	3	
	16 Jan	6	1	
	5 Feb	12	6	
Crazy Woman East*	12 Jan	3		
	16 Jan	5	1	
	5 Feb	3		

Wallow's Creek	12 Jan	5	5	
	15 Jan	6	5	
	16 Jan	6	4	
	5 Feb	5	3	
Powder River Jones South*	14 Jan		1	
	6 Feb	3	1	
Powder River Jones North	14 Jan	5	7	
	6 Feb	4	5	
Clear Creek*	14 Jan	5	4	
	5 Feb	2		3
Old Woman Creek**	3 Feb	5	7	

*Those roosts that were not ground-truthed.

**Those sites considered potential roost.

may utilize waterfowl, particularly Canada geese (Branta canadensis), as a source of food throughout winter (Griffin 1975), it is likely that these birds had a readily available food source.

An incidental finding while ground-truthing roosts was the distribution of carcasses of eagles among roosts. Of all roosts ground-truthed, we found remains of eagles only in the Pine Mountain Roosts and the big Sulfur Springs Roosts. Skeletons of 3 bald eagles, feathered remains of 1 immature bald eagle, and a skeleton of a golden eagle were found in the Pine Mountain Roosts while 3 skeletons of bald eagles, a decomposed carcass of an immature bald eagle, and an undecomposed carcass of an adult bald were found in the Big Sulfur Springs Roost. The carcass of the adult bald eagle was given to the U.S. Fish and Wildlife Service for an autopsy.

Food Habits and Distribution

The most important foods of eagles by occurrence in the study area were sheep and pronghorn. Both hair of sheep and pronghorn were found in castings from all 14 collection sites (Table 2). Occurrence of wool in castings was particularly high in the Powder River Jones North Roost, Wallow's Creek Roost, Pine Ridge Roost and the Tisdale Mountain Roost. Overall, occurrence of pronghorn hair was generally less than that of wool. However, most castings collected from the Seaman Hills Roost contained hair of pronghorn and in some areas, such as the Belle Fourche Roost, neither food source occurred frequently (Table 2).

The only observations of eagles feeding were those on sheep carcasses. Sheep wintered near the Wallow's Creek Roost and the Powder River North Roost, and bald eagles were observed feeding on sheep carcasses in both

Table 2. Frequency of occurrence of domestic sheep, pronghorn, and other* food items found in castings collected at roosts.

Roost	Domestic Sheep % Occ	Pronghorn % Occ	Other % Occ
Antelope Creek (n=15)	26.6	33.3	40.0
Belle Fourche (n=66)	6.1	24.2	69.7
Big Sulfur Springs (n=36)	44.4	36.1	22.2
Keeline (n=130)	21.7	27.4	60.1
Keyton Creek (n=51)	49.0	11.8	39.2
Miller Hills (n=53)	41.5	28.3	40.2
Pine Mountain (n=69)	24.6	26.1	59.2
Little Deer Creek (n=19)	63.1	26.3	42.1
Linch (n=40)	38.0	22.5	77.5
Tisdale Mountain (n=13)	53.8	15.3	38.4
Seaman Hills (n=28)	21.4	71.4	14.2
Pine Ridge (n=11)	63.6	27.2	44.5
Wallow's Creek (n=32)	68.8	28.8	15.5
Powder River Jones North (n=11)	72.7	18.2	18.2
$\bar{x}$ =	42.5	28.4	

*Other food items were mostly Lagamorpha by occurrence although other food items found included cattle, domestic cat (*Felus catus*), mule deer (*Odocoileus hemionus*), prairie dog (*Cynomys* spp.), American robin (*Turdus migratorius*), unidentified Aves, several Rodentia, and unidentified hairs, bones, and claws.

sites during aerial surveys. Other areas where both bald and golden eagles were observed feeding on carcasses of sheep included near the Clear Creek Roost, in the Pine Ridge area north of Kaycee, and along the Cheyenne River near Pine Ridge. Additionally, sheep were observed wintering near the Crazy Woman Creek West Roost, Pine Ridge Roost north of Kaycee, Keeline Roosts, Shool Creek Roost, Antelope Creek Roost, and the Big Sulfur Springs Roosts.

Within the area surveyed, excluding the North Platte River, distributions of bald eagles appear to be associated with large sheep ranches while golden eagles where consistently observed throughout the area but were associated with both large sheep ranches and to the large class pronghorn winter ranges (Table 3). Bald eagle adults and immatures individually and combined had smaller percentages of observations nearest both classes of pronghorn winter ranges than was expected. Larger proportions than expected of the golden eagles observed were found closer to the large class pronghorn winter ranges and were observed in proportion to the expected distance to small class pronghorn winter ranges. Much higher proportions than expected of bald and golden eagles were observed near large sheep ranches although the proportions of golden eagles were less than those of bald eagles (Table 3). Some areas with no sheep did have numbers of bald eagles. Both bald and golden eagles were found wintering along Bates and Stinking Creeks south of Casper. This area was a critical winter range for pronghorn and mule deer (*Odecoileus hemionus*) and likely provided a consistent food supply for these eagles.

Table 3. Distances between eagles and pronghorn winter range, and sheep ranches.

	Pronghorn Population[1] >3,000			Pronghorn Population < 3,000			Sheep[2] > 2,000		
	% < 1 km	% > 1 km and < 5 km	% > 5 km	% < 1 km	% > 1 km and < 5 km	% > 5 km	% < 1 km	% > 1 km and < 4 km	% > 5 km
Bald Eagle Adult n = 268	10.4	12.6	76.9**	9.7	10.4	79.9*	60.1	10.9	29.1***
Bald Eagle Immature n = 111	11.7	9.0	79.3*	7.2	23.4	69.4**	56.8	21.6	21.6***
Bald Eagle n = 379	10.8	11.6	77.5**	9.0	14.2	76.8***	59.1	14.0	26.9***
Golden Eagle n = 127	29.9	13.3	56.6***	17.3	12.6	70.1*	29.1	7.1	63.8**
Random n = 303	16.7	15.5	68.3	14.2	10.9	74.9	18.5	7.2	73.9

*$X^2 < 5.99$, d.f. = 2, $P > .05$ **$X^2 > 5.99$, d.f. = 2, $P < .05$ ***$X^2 > 10.6$, d.f. = 2, $P < .005$

[1]Populations and distributions of winter ranges of pronghorns were provided by the Wyoming Game and Fish Department.

[2]County Soil Conservation Service Offices, and Agriculture Soil Conservation Service provided data on distribution of sheep ranches greater than 2000 sheep.

Physiographic and Forest Stand Characteristics of Upland Roosts

Direction of wind, number of days of strong winds (e.g. > 17 mph), and average wind speed varied between sites. Casper had the highest average wind speed, most days with strong winds and had a prevailing direction from the southwest (Table 4). In contrast, Sheridan had a relatively low average wind speed, few days with strong winds, and the prevailing direction of wind was from the west. Most upland roost examined were in localities most likely influenced by weather characteristics similar to those of Casper, while roosts in the riparian areas were nearest Sheridan and probably were influenced by similar weather patterns.

Of the 16 physiographic measurements taken from roost and nonroost sites, only 5 variables differed significantly from random sites. Roosts tended to be found on relatively steep slopes (X^2 = 14.6, d.f. = 2, P < .0005) (Table 5) with a northeasterly aspect (X^2 = 45.6, d.f. = 4, P < .005) (Table 6). Differences between random and roost were also found between slope (X^2 = 19.03, d.f. = 2, P < .0005) and aspect (X^2 = 46.1, d.f. = 4, P< 0.005) of the opposing valley wall which was likely associated with the slope and aspect of the roost. Degree of view from the midpoint of the slope also differed from nonroost sites (X^2 = 13.4, d.f. = 6, P .05) suggesting that roosts were located in valleys surrounded by other ridges. Also, no opposing valley slopes were found in 14.2% of the nonroost sites while all roosts had opposing slopes. Based on measurements of physiography, roosts in upland sites were located in areas likely to be more protected from adverse weather conditions and the prevailing southwesterly winds.

Other variables measured at roosts were similar to random points (Table 5). Both the Antelope Creek Roost and the Southwest Canyon (Pine Mountain) Roost were only 0.6 km from an oil well or drilling activity

Table 4. Summary statistics for wind speed and direction for 2 sites in northeastern Wyoming.

Site	Direction From	Average Wind Speed (MPH)	No. of Days	No. of Days Wind >17 MPH
Casper (1981-84)	N	9.5	32	1
	NE	10.2	24	0
	E	9.3	9	1
	SE	10.8	4	0
	S	12.6	10	2
	SW	17.3	366	193
	W	11.0	76	4
	NW	8.9	20	0
	$\bar{x}$=SW (235°)	11.2	Totals 541	201
Sheridan (1981-84)	N	5.3	36	0
	NE	4.2	7	0
	E	4.2	14	0
	SE	5.1	25	0
	S	5.0	59	0
	SW	5.5	63	0
	W	6.9	163	0
	NW	8.8	174	5
	$\bar{x}$ = W (277.5°)	5.6	Totals 541	5

Table 5. Mean measurements of physiographic features of roost and nonroost sites.

Variable	Roost (n=23)	Nonroost (n=92)
Length of Ridge of Roost (m)	329.9	356.0
Width of Valley (m)	243.7	382.9
Slope of Roost (%)	43.5[1]	37.4
Slope of Opposite (%)	45.1[2]	32.6[3]
Height of Valley Wall (m) of Roost	50.1	59.5
Height of Opposite Valley (m) Wall	58.1	52.5[3]
Degrees of View (d°)	52.0[4]	103.4
Distance to:		
Dwelling (km)	4.3	4.7
Oil Well (km)	5.5	5.7
Improved Road (km)	3.0	3.2
Unimproved Road (km)	0.3	0.6
Riparian Area (km)	8.8	10.0

[1] $X^2 = 14.6$, d.f. = 2, $P < .0005$

[2] $X^2 = 19.0$, d.f. = 2, $P < .0005$

[3] N = 79

[4] $X^2 = 13.4$, d.f. = 6, $P < .05$

Table 6. Mean orientations, r values[1], and 95% confidence intervals of orientation measurements of roost and random sites.

	Roost (n=23)	r	95% Confidence Interval	Nonroost (n=92)	r	95% Confidence Interval
Aspect of Roost	33.3°[2]	0.89	±18°	31.2°	0.14	> ±90°
Aspect of Opposite Slope	232.8°[3]	0.74	±24°	248.6°	0.21	±72°
Orientation of Canyon	41.1°	0.01	>±90°	350.3°	0.1	> ±90°
Center of View	38.7°	0.35	>±90°	2.8°	0.1	> ±90°

[1] r = 1.0 shows all points align in 1 direction.

[2] $X^2 = 45.6$, d.f. = 4, $P < .005$

[3] $X^2 = 46.1$, d.f. = 4, $P < .0005$

[4] N = 79

(Appendix G, Table 1). The Box Elder Creek Roost was only 1 km from an improved road while all roosts had an unimproved road within 1 km. Unimproved roads allowed vehicle access to most roosts in the Rochelle Hills and Miller Hills. With the exception of unimproved roads, none of these man-made artifacts were visible from the roost site based on field observations.

Species of tree used for roosting reflected those species available in roosts. Most trees used for roosting were ponderosa pines (Pinus ponderosa) (Table 7). The only other species of tree used for roosting were Douglas fir (Psuedotsuga menzeisii) in the Little Deer Creek West Roost and limber pine (Pinus flexilis) in the Big Sulfur Springs Roosts.

Size class, height class, structure class, percent snags, percentage of trees infected by beetles, densities of trees and the size of the roost varied among roosts (Table 7). The largest trees were located in the Casper Mountains, Pine Mountain, Broken Horn, and Pine Ridge while the smallest trees were in the Rochelle Hills area. The most closed structures of trees were found in the Casper Mountains and structures of trees among other roosts were variable (Table 7). Snags were found in all roosts although the percentage of snags fluctuated. Infestations by bark beetles were common in roosts on Casper Mountain, Pine Mountain, Pine Ridge and in the Broken Horn area but only Antelope Creek had beetles in those roosts in the Rochelle Hills area.

Densities of trees both greater than and less than 28 cm dbh, and area of the roost differed among roosts (Table 7). In the Casper Mountain roost sites, densities of trees in both size classes were relatively high. In contrast, the Big Sulfur Springs West Roost had low densities of trees in both classes while those roosts in the Keeline area had relatively high

Table 7. Forest stand characteristics in roost sites.

Roost	Species of Tree[1]	DBH Class	Height Class	Structure[2]	% Snags	% Infested by Beetles	Density of Trees >28 cm dbh	Density of trees >28 cm dbh	HA Surveyed
Antelope Creek	POPI	5.76	2.76	2.57	19.0	4.8	33.3	316.6	.18
Belle Fourche	POPI	5.83	2.86	2.54	5.7	0.0	90.8	104.5	.30
Big Sulfur Springs West	POPI,LIPI	6.70	2.20	2.49	8.2	28.6	60.6	78.6	.60
Big Sulfur Springs East	POPI,LIPI	6.10	2.10	3.82	44.0	0.0	74.7	128.8	1.10
Cheyenne River	POPI	6.58	3.80	2.50	7.1	14.3	40.1	115.9	.17
Keeline A	POPI	6.26	4.00	2.76	5.3	0.0	66.5	184.3	.27
Keeline B	POPI	5.90	3.60	2.58	8.3	0.0	70.8	490.4	.15
Keeline C	POPI	6.10	3.90	3.30	36.4	0.0	66.3	723.2	.14
Keeline D	POPI	5.77	3.60	2.50	6.7	0.0	107.8	139.3	.28
Keyton Creek South	POPI	5.66	3.8	2.29	9.8	0.0	64.7	612.0	1.1
Keyton Creek North	POPI	5.50	4.3	3.40	14.3	0.0	70.8	266.0	.30
Miller Hills North	POPI	5.76	3.0	3.35	11.8	0.0	53.4	342.0	.19
Miller Hills South	POPI	5.50	2.7	2.70	9.5	0.0	83.3	293.7	.20
Baerthel Canyon (Pine Mountain)	POPI	6.60	3.1	2.65	19.2	9.6	86.5	151.9	1.09
Southwest Canyon (Pine Mountain)	POPI	6.60	3.8	2.60	19.6	0.0	109.6	260.1	1.20
School Creek	POPI	6.30	3.3	3.20	17.4	4.3	88.3	244.2	.19

Table 7. Continued.

Box Elder Creek	POPI	6.54	4.73	2.67	20.0	26.7	98.9	862.9	1.50
Jackson Canyon	POPI	6.56	4.19	2.10	3.7	0.0*	54.8	810.3	1.8
Little Deer Creek	POPI,DOFI	6.20	4.57	2.19	4.2	8.3	74.7	324.1	.80
Little Red Creek	POPI,DOFI	5.85	4.44	1.94	5.9	17.6	78.5	1396.1	4.2
		6.07	3.54	2.70	13.8	5.7			

POPI Ponderosa pine (*Pinus ponderosa*)
LIPI Limber pine (*P. flexilus*)
DOFI Douglas fir (*Pseudotsuga menziesii*)

*No trees >28 cm dbh were infected by beetles in plots sampled; however, 4.8% (n=322) of all trees were infected.

[2]Adapted from Keen (1948)

densities of large trees and low densities of small trees. The areas of roosts were also larger in the Casper Mountains which probably reflects the topography and extent of coverage of slopes by trees in the region. Most roosts in other areas were in small draws that had comparatively smaller slopes and less coverage of trees on slopes.

Characteristics of roost trees were also different among roosts (Table 8). The largest roost trees were found in the Casper Mountain and Pine Mountain area and the structure of roost trees was also variable. Nearly all roost trees were located below the horizon and many were infected by beetles in the Big Sulfur Springs West Roost, Cheyenne River Roost, Baerthel Canyon (Pine Mountain) Roost, and all roosts in the Casper Mountains (Table 8).

Within roosts, eagles selected the largest, more open structured trees for roosting. Comparisons among roost trees and characteristics of all trees in roosts larger than 28 cm dbh showed that size class ($\bar{X}$ = 6.75 vs. $\bar{X}$ = 6.07, p = .01), height class ($\bar{X}$ = 4.15 vs. $\bar{X}$ = 3.54, p = .0013), and structure of trees ($\bar{X}$ = 3.13 vs. $\bar{X}$ = 2.70, p = .0015) were larger than those in the forest stand. Snags were also more common in the sample of roost trees than in the forest stand ($\bar{X}$ = 22.2% vs. $\bar{X}$ = 13.8%, p = .018) while roost trees infected with beetles were not more common than in the forest stand ($\bar{X}$ = 10.1 vs. $\bar{X}$ = 5.7, p = .10).

Comparisons of characteristics of forest stands between roosts and nonroosts showed similar trends as between roost trees and trees within roosts. Sixteen roosts were compared to 57 nonroost sites. All variables measured, except percent of trees infected by beetles, differed ($P < .05$) among roost and nonroost sites (Table 9). Roosts tended to have larger, more open structured trees, with relatively higher percentages of snags,

Table 8. Characteristics of roost trees in upland roosts in northeastern Wyoming.

Roost	Species of Tree[1]	No. of Trees	DBH* Class	Height* Class	Structure[2]*	% Snags*	% of Trees Below Hor.	%Infected by Beetles
Antelope Creek	POPI	7	5.56	3.11	2.89	14.3	100.0	11.1
Belle Fourche	POPI	7	6.86	3.57	3.29	14.3	71.4	0.0
Big Sulfur Springs West	POPI	5	6.80	3.80	3.80	60.0	100.0	40.0
	LIPI	2	8.50	5.00	2.50	0.0	100.0	0.0
Big Sulfur Springs East	POPI	3	6.33	3.00	4.00	33.3	100.0	0.0
	LIPI	7	5.42	2.00	4.00	42.9	100.0	0.0
Cheyenne River	POPI	4	8.50	5.00	3.5	25.0	100.0	50.0
Keeline A	POPI	16	6.31	3.88	2.94	6.3	81.3	0.0
Keeline B	POPI	5	6.60	4.20	3.40	20.0	100.0	0.0
Keeline C	POPI	6	6.50	4.00	3.50	33.3	100.0	0.0
Keeline D	POPI	7	5.88	4.25	2.62	33.3	100.0	0.0
Keyton Creek A	POPI	11	6.73	4.55	2.64	36.4	100.0	0.0
Keyton Creek B	POPI	12	4.75	3.25	2.08	16.6	100.0	0.0
Miller Hills A	POPI	10	5.60	3.20	3.70	10.0	100.0	0.0
Miller Hills B	POPI	9	5.33	2.89	3.67	33.3	100.0	0.0
Baerthel Canyon (Pine Mountain)	POPI	15	7.90	4.0	3.27	33.3	100.0	26.7
Southwest Canyon (Pine Mountain)	POPI	18	8.8	5.31	2.96	11.1	100.0	5.6

School Creek	POPI	9	7.11	3.78	3.33	22.2	100.0	0.0
Box Elder Creek	POPI	43	7.00	5.19	2.88	20.9	83.7	34.9
	DOFI	0						
Jackson Canyon	POPI	25	7.25	5.10	2.58	4.0	100.0	16.0
Little Deer Creek	POPI	11	7.27	5.00	3.35	9.1	100.0	18.2
	DOFI	12	6.50	5.10	2.41	0.0	100.0	0.0
Little Red Creek	POPI	8	7.13	5.25	2.13	25.0	100.0	0.0

[1] POPI Ponderosa pine (*Pinus ponderosa*)
LIPI Limber pine (*P. flexilus*)
DOFI Douglas fir (*Pseudotsuga menziessii*)

[2] Adapted from Keen (1943)

*These characteristics differ significantly from those of the forest stand at $p < .01$.

Table 9. Characteristics of trees measured at roosts and non-roost sites during 1985.

Roost	Species of Trees	Structure[2*]	Snags (%)*	DBH* Class	Height* Class	Beetles (%)	Density*	HA Surveyed
Antelope Creek	POPI[1]	2.57	19.0	5.76	2.76	4.8	33.3	.18
Nonroost (3)[3]		2.29	0.0	5.24	2.19	0.0	23.1	.23[4]
Belle Fourche	POPI	2.54	5.7	5.83	2.86	0	90.8	.30
Nonroost (4)		1.67	0.0	6.18	3.12	0	53.0	.19
Big Sulfur Springs West	POPI,LIPI[1]	2.49	8.2	6.70	2.2	28.6	60.6	.60
Nonroost (3)		2.22	28.6	6.10	2.1	0	37.8	.55
Big Sulfur Springs East	POPI,LIPI	3.72	44.0	6.10	2.1	0	74.7	1.10
Nonroost (3)		2.63	7.4	5.90	2.2	11.1	37.1	.27
Cheyenne River	POPI	2.50	7.1	6.58	3.80	14.3	40.1	.17
Nonroost (3)		2.25	0.0	6.21	2.95	14.3	25.3	.31
Keeline (A)	POPI	2.76	5.3	6.26	4.0	0	66.5	.27
Nonroost (4)		2.42	5.5	5.99	3.3	0	31.7	.35
Keeline (B)	POPI	2.58	8.3	5.9	3.6	0	70.8	.15
Nonroost (4)		2.10	0	5.6	3.3	0	27.1	.16
Keeline (C)	POPI	3.3	36.4	6.1	3.9	0	66.3	.14
Nonroost (3)		2.3	4.0	5.8	3.3	0	87.4	.20
Keeline (D)	POPI	2.50	6.7	5.77	3.6	0	107.8	.28
Nonroost (4)		2.52	3.0	5.69	3.31	3.0	71.5	.48
Keyton Creek South	POPI	2.29	9.8	5.66	3.80	0	64.7	1.1
Nonroost (4)		2.25	0	5.40	3.48	0	53.5	.34
Keyton Creek North	POPI	3.40	14.3	5.50	4.3	0	70.8	.30
Nonroost (4)		2.51	2.2	5.45	3.4	2.2	64.4	.25

Miller Hills (A)	POPI	3.35	11.8	5.76	3.0	0	53.4	.19
Nonroost (4)		2.25	5.8	5.41	3.2	0	63.8	.14
Miller Hills (B)	POPI	2.70	9.5	5.50	2.7	0	83.3	.20
Nonroost (4)		2.03	0	5.36	3.0	0	53.8	.16
Baerthel Canyon	POPI	2.65	19.2	6.60	3.1	9.6	86.5	1.09
(Pine Mountain)		2.38	4.5	6.41	2.9	3.5	61.0	.84
Nonroost (4)								
Southwest Canyon	POPI	2.60	19.6	6.60	3.8	0	109.6	1.2
Pine Mountain		2.16	7.7	6.42	2.9	2.5	77.8	.37
Nonroost (3)								
School Creek	POPI	3.20	17.4	6.3	3.3	4.3	88.3	.19
Nonroost (3)		1.93	4.3	5.5	3.4	0	30.5	.19

[1] POPI - Ponderosa pine (Pinus ponderosa)
LIPI - Limber pine (Pinus flexilis)

[2] Adapted from Keen (1943)

[3] Number of nonroost plots

[4] Average area among nonroost plots

*These characteristics of roosts differed from nonroosts at P <.01.

and higher densities of trees larger than 28 cm dbh than neighboring nonroost slopes.

Discussion and Management Recommendations

The study area had been previously surveyed for roosts of eagles in Campbell, Sheridan, and Johnson County. Since we found additional roosts in these counties and another was reported after our surveys (R. Kiewit pers. comm. 1985), there are likely other roosts not yet documented and shows the need to intensively survey areas that are being considered for development. Searches should be conducted by aircraft and on the ground. Aerial surveys are the most efficient means of covering large areas, however, the use of roosts by eagles is variable (Bagdonas et al. 1984) and it is difficult to reach many potential sites by aircraft at dawn when eagles are most likely to be on roost trees. We documented several roosts during aerial surveys, but ground searches yielded as many new locations of roosts. Roost sites can easily be recognized on the ground by looking for white-wash on trees and castings on the ground.

Food availability is an important factor influencing the locations of communal night roosts (Steenoff et al. 1981, Keister and Anthony 1984). Foods of eagles in our study area were largely ungulates which were likely taken as carrion. These data compare well to other food habits data from our study area. Roosts in this study previously examined by Jenkins et al. (1980) included the Jackson Canyon, Crazy Woman (east), Box Elder Creek, Powder River Jones (south), Clear Creek, Powder River (Middle Fork), and the Pine Mountain Roosts. Sheep were reported in castings collected in all 7 roosts (Jenkins et al. 1981). Other foods reported included pronghorn from 4 roosts, jackrabbits (Lepus spp.) from 2 roosts, deer from 3 roosts,

and waterfowl from 1 roost. Frequency of occurrence of pronghorn, white-tailed jackrabbit (Lepus townsendii) and domestic sheep were 40.8%, 35.9%, and 30.7%, respectively, in castings collected at the Belle Fourche Roost between 1978 and 1981 (Hayden 1984, p:30). This was a greater occurrence of pronghorn and sheep than in our 1985 samples. Golden eagles in the same area had higher percentages of occurrence of white-tailed jackrabbits and pronghorn, and less percent occurrence of sheep than did bald eagles in the same vicinity (Hayden 1984). In Colorado and in Utah, mostly remains of jackrabbits were found in castings (Edwards 1969, Harmata 1984). Many biologists in our study area felt jackrabbit populations were relatively low but there is little data for support. We would expect distributions of eagles to differ from this study in years of high jackrabbit populations or in years with severe winter weather making other carrion available to eagles.

The high occurrence of pronghorn and sheep in castings from eagles (Jenkins et al. 1980, Hayden 1984) tend to support our data showing that golden eagles were associated with both pronghorn winter ranges and sheep ranches, while bald eagles were associated more with sheep ranches. In areas where there are known to be winter ranges of ungulates, or areas where sheep ranching is a major land use, resource managers should consider these areas likely to hold eagle roosting sites and should be surveyed for locations of roosts. These surveys should be conducted over several winters of varying severity since this would likely influence the availability of carrion and the subsequent use of these areas by eagles.

Characteristics of Roosts

Roosts in upland sites in northeastern Wyoming were located on relatively steep, northeasterly exposed slopes. Little work has been done on the physiography of roosts but 3 roosts in canyons in Utah (Swisher 1964, Edwards 1969) and 3 roosts in the Klamath Basin in Oregon and California also had northerly and northeasterly exposures (Keister and Anthony 1983). Slopes in northeastern Wyoming were likely selected for protection from the strong winds. Mean aspects of roosts were similar to the mean direction of wind measured at Casper (Figure 2).

Forest stand characteristics of roosts suggest that eagles use forest stands with relatively higher densities of larger (> 28 cm dbh), more opened structured trees, and more snags than surrounding areas. Stands are composed of uneven sized trees and the relatively large, open structured trees, and snags are the preferred roost trees.

Roost trees are typically among the oldest trees within a forest stand requiring many years to grow to the preferred height and structure (Keister and Anthony 1983). Potential feeding sites within resource areas should be identified and likely roosting sites should be located. In northeastern Wyoming, most roosts were located on slopes with a northeasterly aspect and with relatively high densities of large conifers and the presence of snags. Sites with these characteristics should be considered potential roost sites and should be examined for use by eagles.

The use of artificial roosting structures should be explored as a potential mitigation procedure. We recommend that artificial snags be placed on steep northeasterly slopes in well protected valleys approximately two-thirds from the bottom of the slope in areas where there is an available food source. Another possibility would be creating roost trees by selectively pruning or girdling large trees on northeasterly

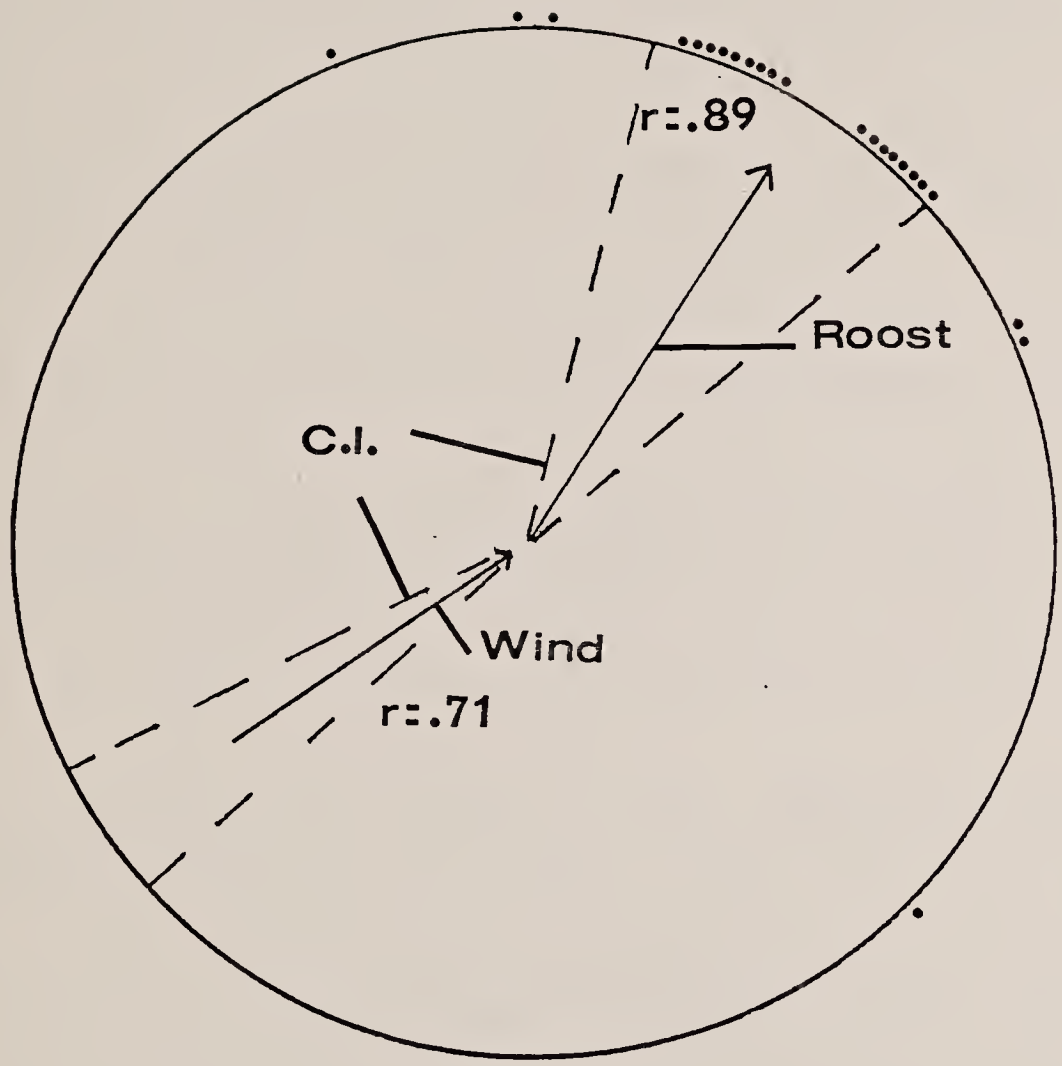

Figure 2. Mean aspect, r values', and confidence intervals of roosts and wind direction taken from Casper.

facing slopes. Artificial roosting structures used in Colorado were inexpensive and were used by both bald and golden eagles (Harmata 1984). This possibility needs further investigation since energy developments may threaten some known roost sites (Dahlem pers. comm. 1985).

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Appendix A. Locations of Roosts found in Northeastern Wyoming.

Table 1. Names and legal locations of roosts of bald eagles that were previously documented and roosts found during surveys during winter 1984-85.

Roosts in Uplands			
Previously Known Roosts		Roosts Found During 1984-85	
Box Elder Creek	T32N R75W S13	Little Deer Creek West	T32N R76W S10
Jackson Canyon	T32N R80W S18	Little Deer Creek East	T32N R76W S11
Little Red Creek	T32N R80W S25, S26	Seaman Hills	T35N R61W 57,58
Baerthel Canyon	T35N R84W S24 T35N R83W S19	North Fork Cheyenne River	T37N R67W S12
		Pine Ridge A	T40N R77W S27
Pine Mountain West Roosts			
Southwest Canyon	T35N R84W S34	Pine Ridge B	
West Canyon	T35N R84W S34		
West Ridge South	T34N R84W S3	Pine Ridge C	T39N R77W S11
Miller Hills A	T39N R69W S18	Big Sulfur Springs West	T39N R84W S36
Miller Hills B	T39N R69W S24	Big Sulfur Springs East	T39N R84W S32
Miller Hills C	T39N R69W S18	Keyton Creek North	T41N R86W S6
Keyton Creek South	T41N R69W S1	Linch	T42N R78W S12
Antelope Creek	T41N R70W S25	Tisdale Mountain	T42N R81W S33
School Creek	T42N R69W S5	Keeline C	T43N R69W S14
Keeline A	T43N R69W S15	Keeline D	T43N R69W S15
Keeline B	T43N R69W S16	Pine Ridge (north of Kaycee)	T44N R81W S22
Deer Creek	T47N R70W S22		

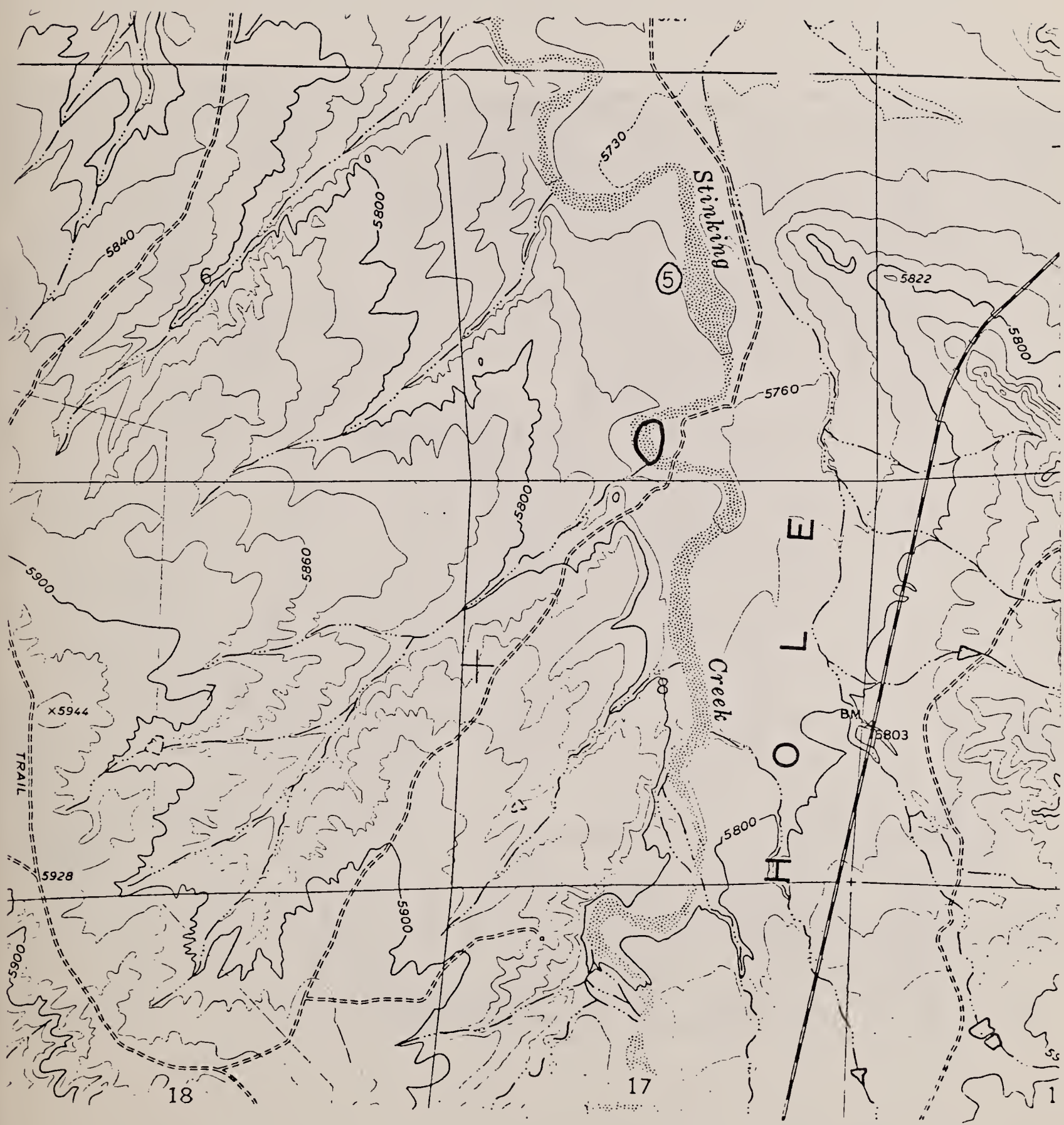
Roosts in Riparian Areas			
Previously Known Roosts		New Roosts	
Crazy Woman East	T48N R80W S20	Stinking Creek	T30N R80W S5
Powder River (Jones) South	T53N R77W S11	Cole Creek	T34N R77W S36

Table 1. Continued.

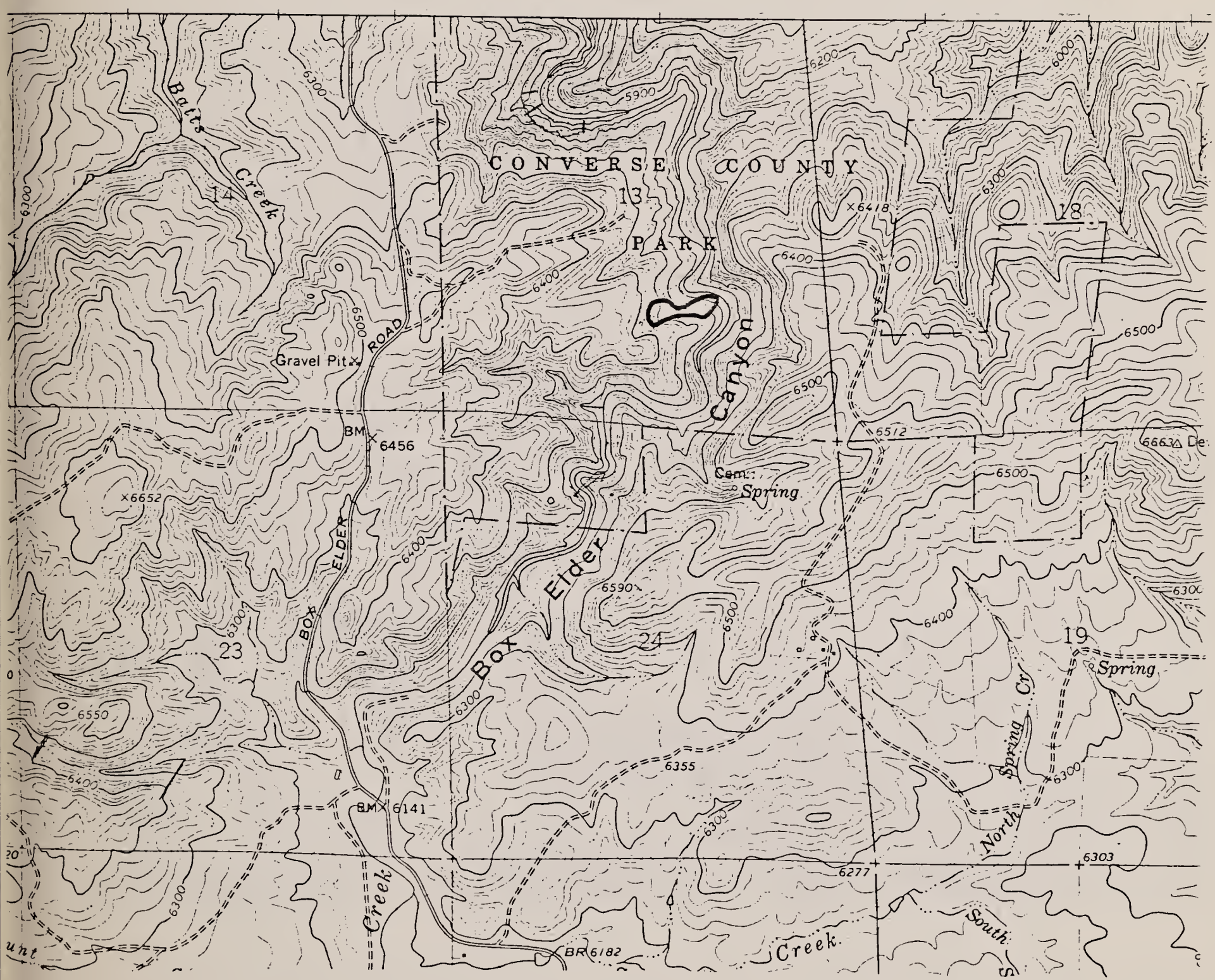
Clear Creek	T55N R78W S30	Powder River (Kaycee)	T43N R80W S19
		Powder River Bowman Flat	T47N R78W S1, S2
		Crazy Woman Creek West	T47N R81W S9
		Pond-West Fork of Dry Trabing Creek	T47N R81W S35
		Powder River Culp Flat	T48N R77W S31 T48N R77W S17, S20
		Wallow's Creek	T48N R81W S1
		Powder River (Jones) North	T54N R77W S36

Stinking Creek Roost

(T30N R80W S5)



Box Elder Creek Roost
(T32N R75W S13)



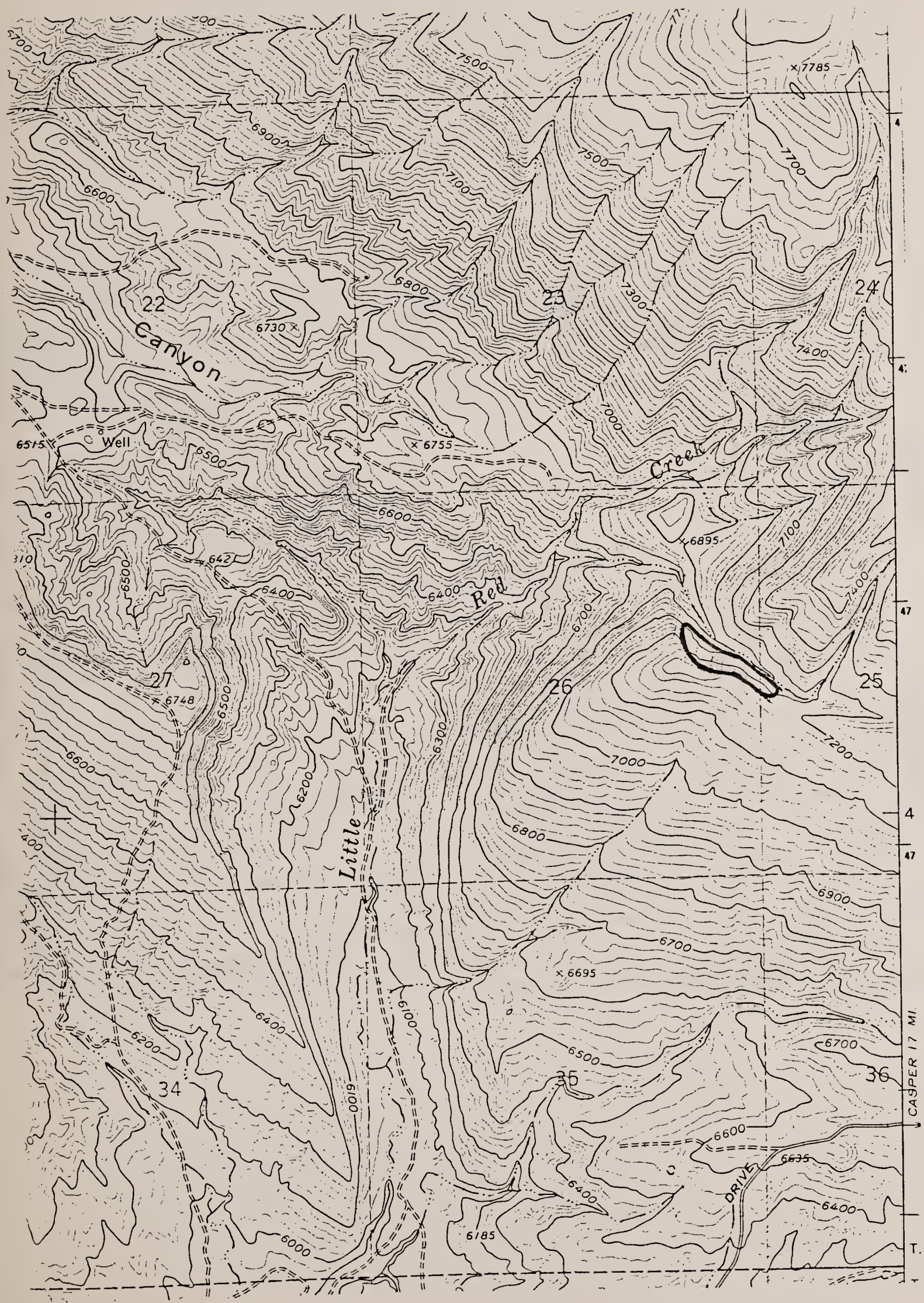
Little Deer Creek Roosts West and East

(T32N R76W S10,11)

Jackson Canyon Roost

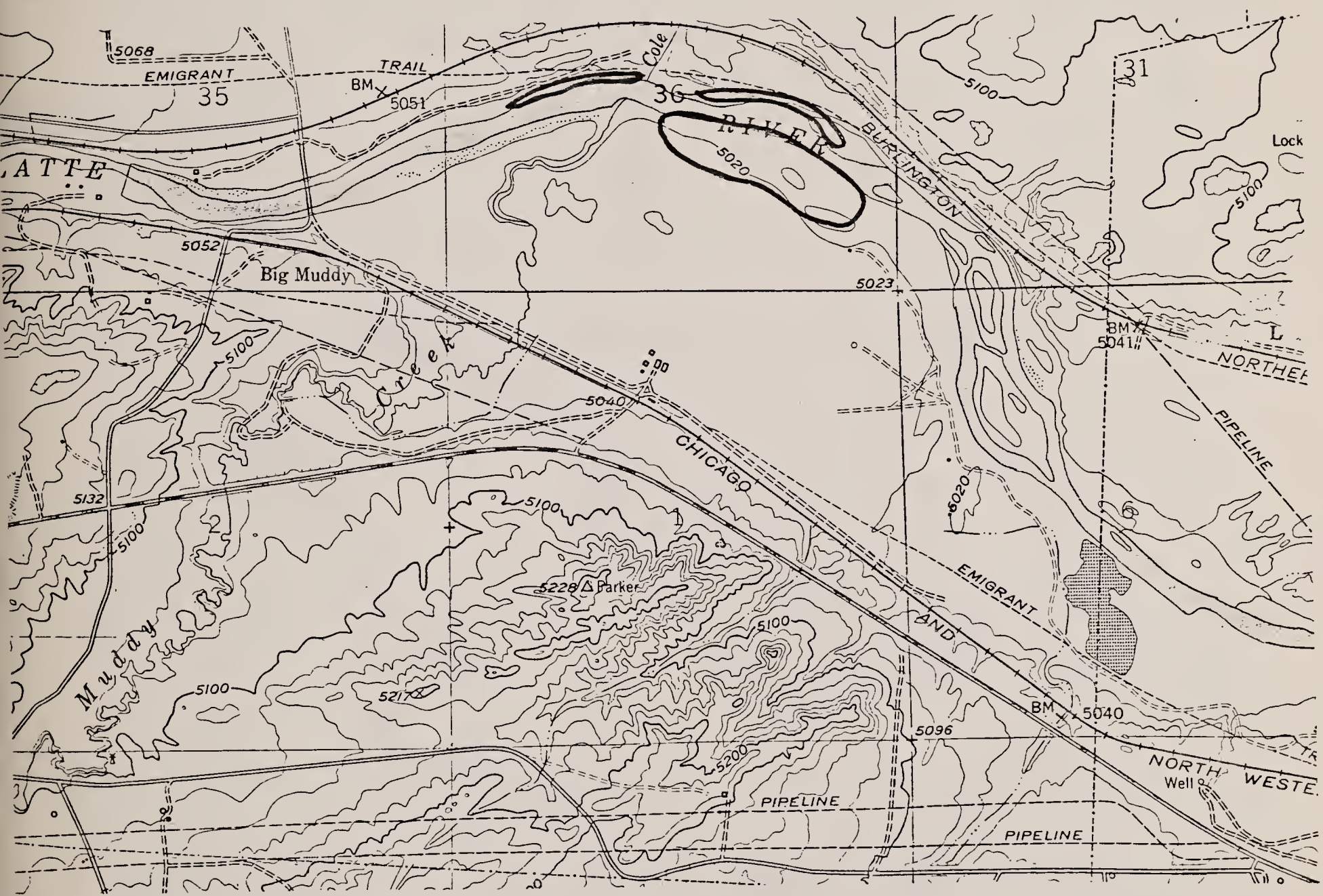
(T32N R80W S18)

Little Red Creek Roost
(T32N R80W S25,26)



Cole Creek Roost

(T34N R77W S36)



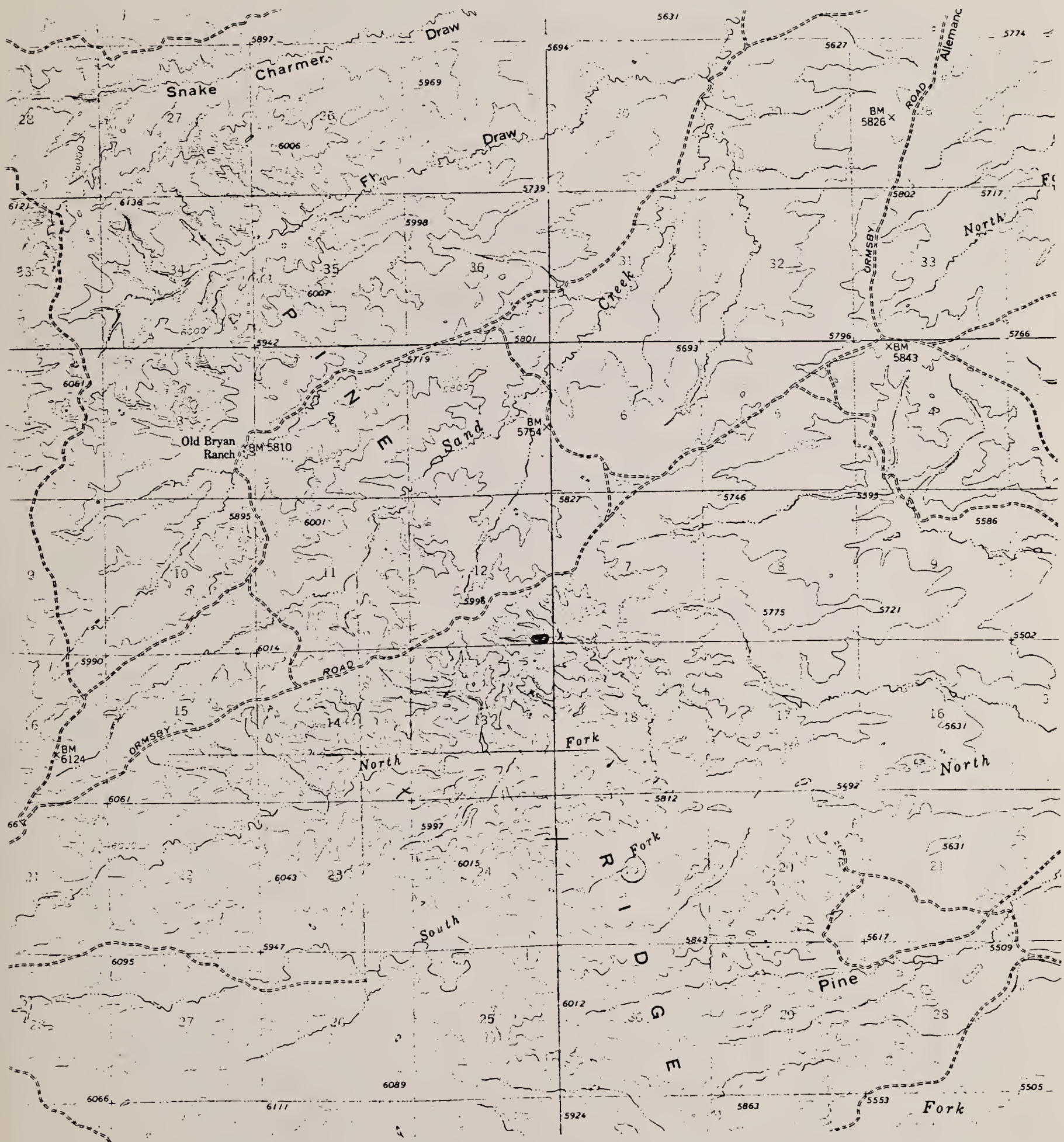
Seaman Hills Roost
(T35N R61W S7,8)

Baerthel Canyon Roost - Pine Mountain
(x = Roost trees)

(T35N R84W S24, T35N R83W S19)

Pine Mountain West Roosts
(T35N R84W S34,33, T34N R84W S3)
(x = Roosts trees)

North Fork Cheyenne River Roost
(T37N R76W S12)

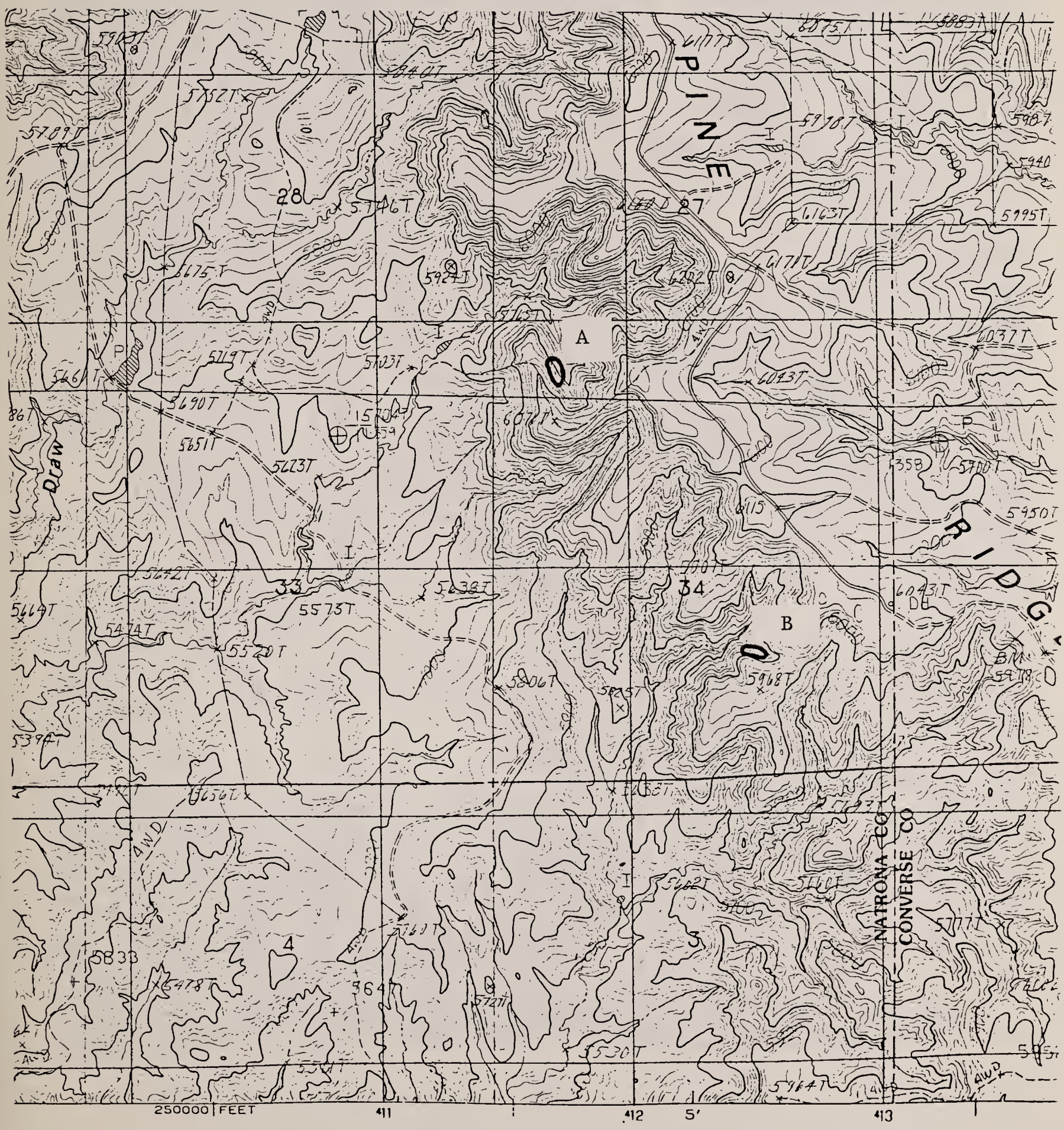


Miller Hills (A, B, and C)
(T39N R69W S24, T39 R67 S18)
(x = Roost trees)

Pine Ridge (C)
(T39N R77W S11)

Big Sulfur Springs Roost East and West
(T39N R84W S36, S32)
(x = Roost trees)

Pine Ridge (A and B)
(T40N R77W S27,34)



Keyton Creek Roost North and South
(T41N R69W S1, T41N R68W S6)
(x = Roost trees)

Antelope Creek Roost
(T41N R70W S25)

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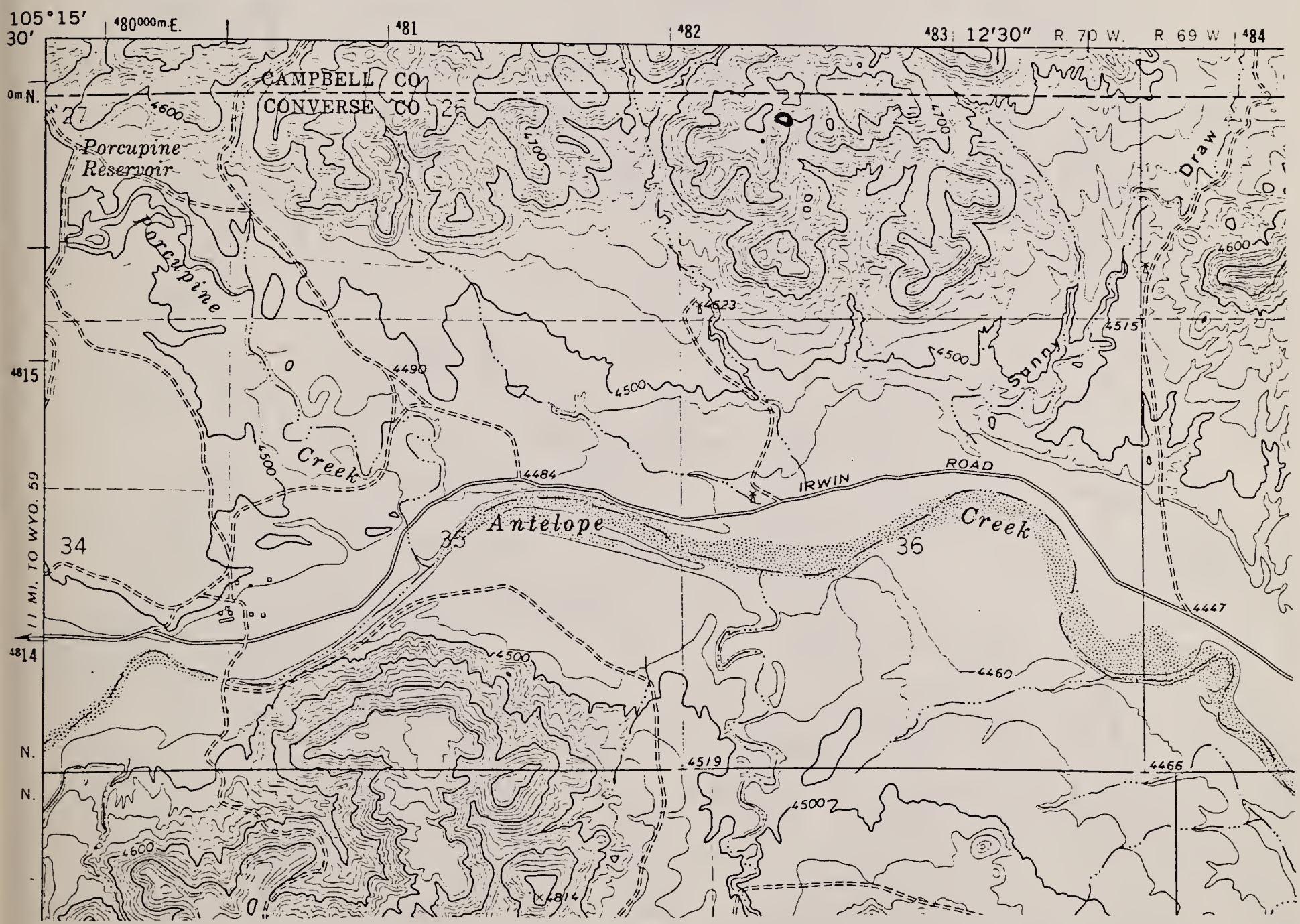
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

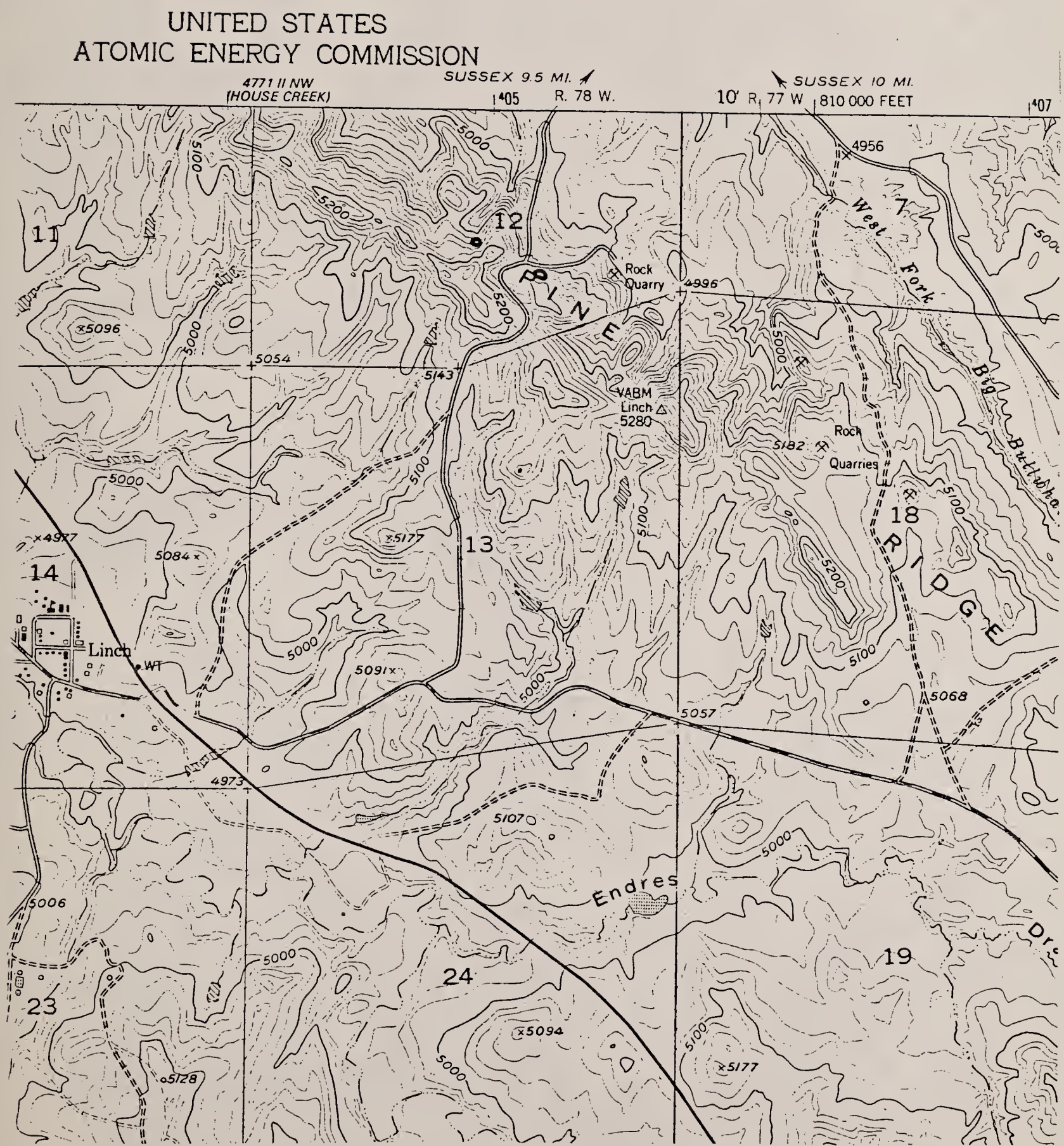


School Creek Roost

(T42N R69W S5)

Linch Roost

(T42N R78W S12)



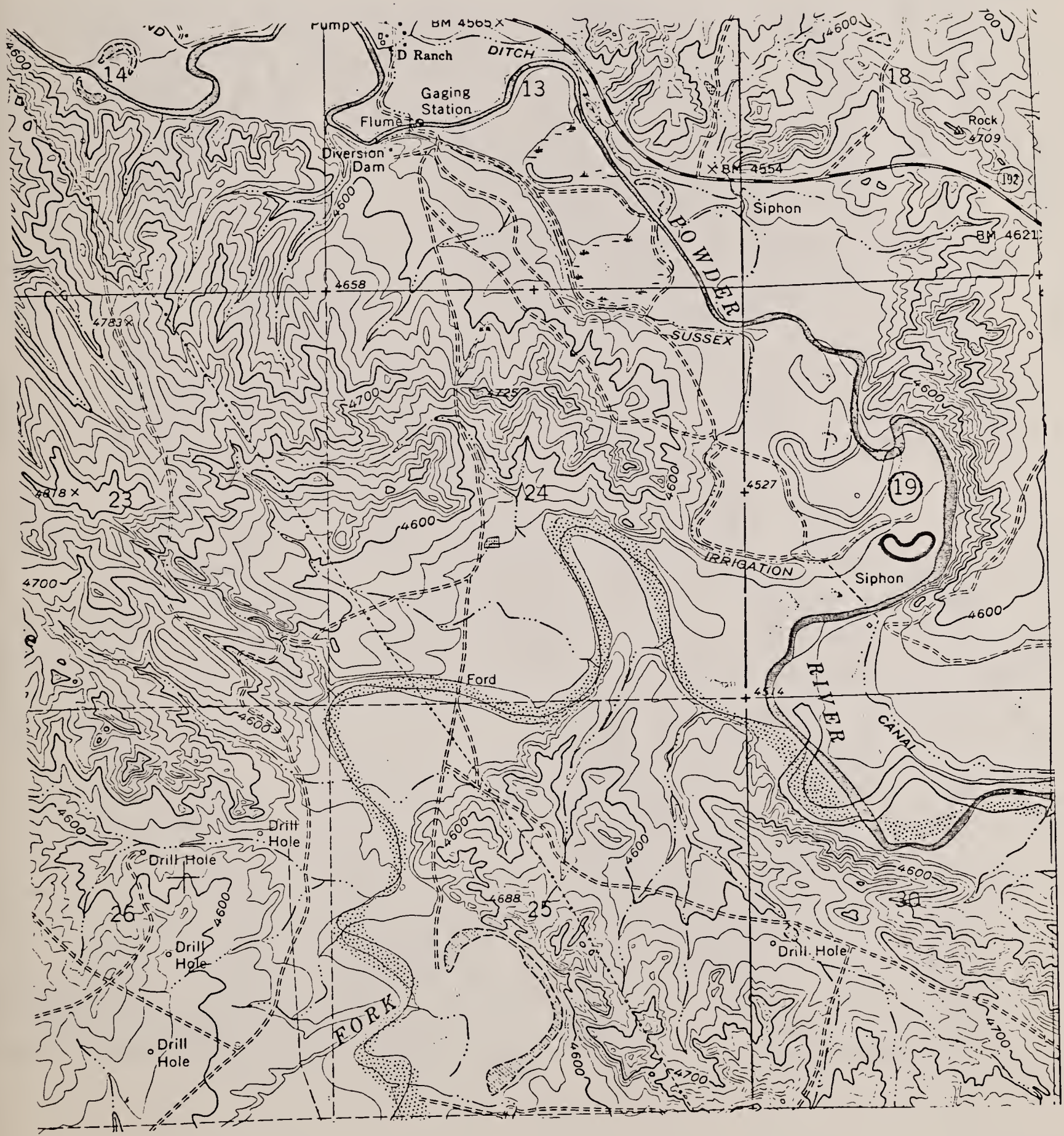
Tisdale Mountain Roost
(T42N R81W S33)

Keeline Roosts (C and D)
(T43N R69W S14,15)

Keeline Roosts (A and B)

(T43N R69W S15,16)

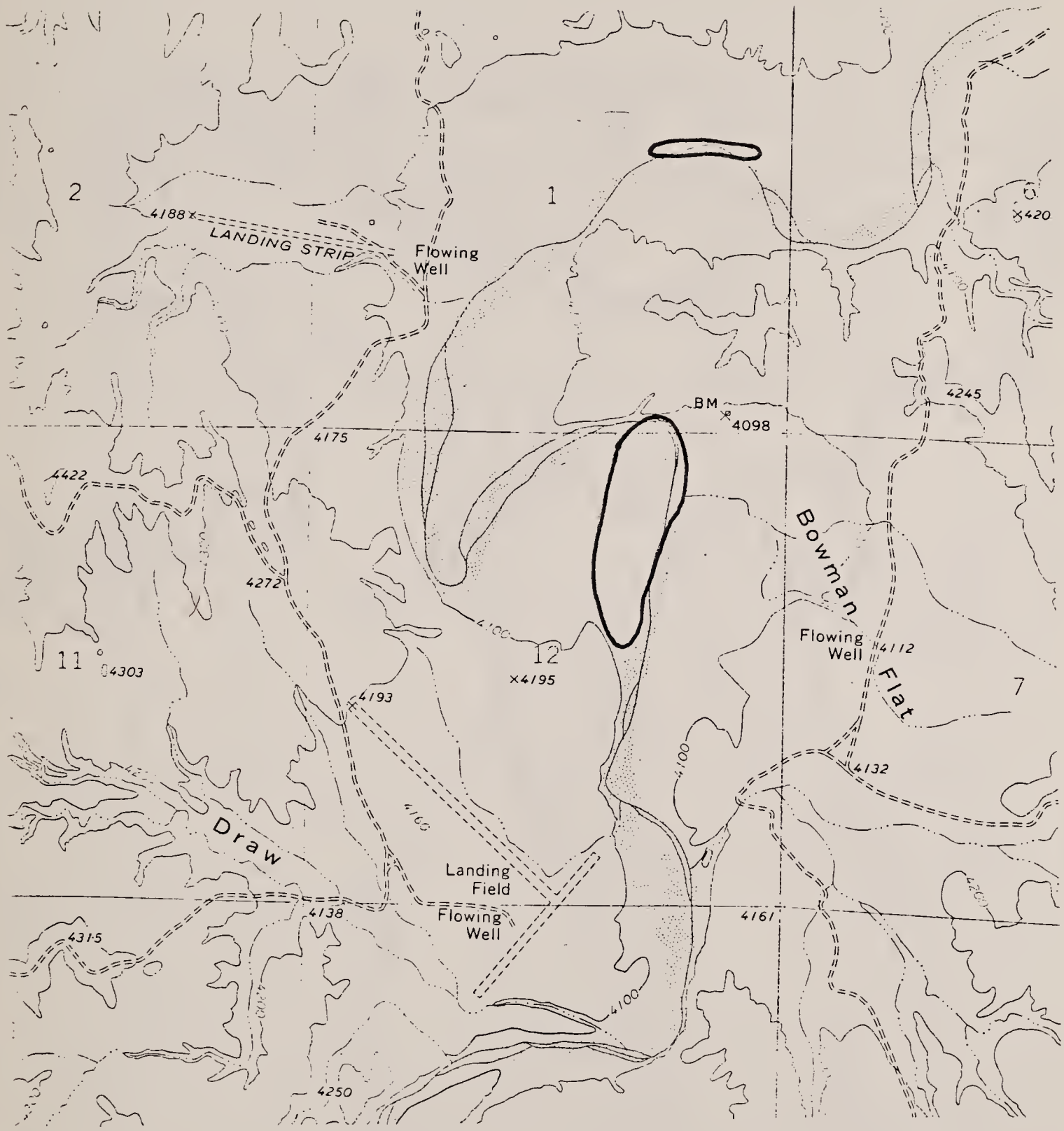
Powder River Roost (Kaycee)
(T43N R80W S19)



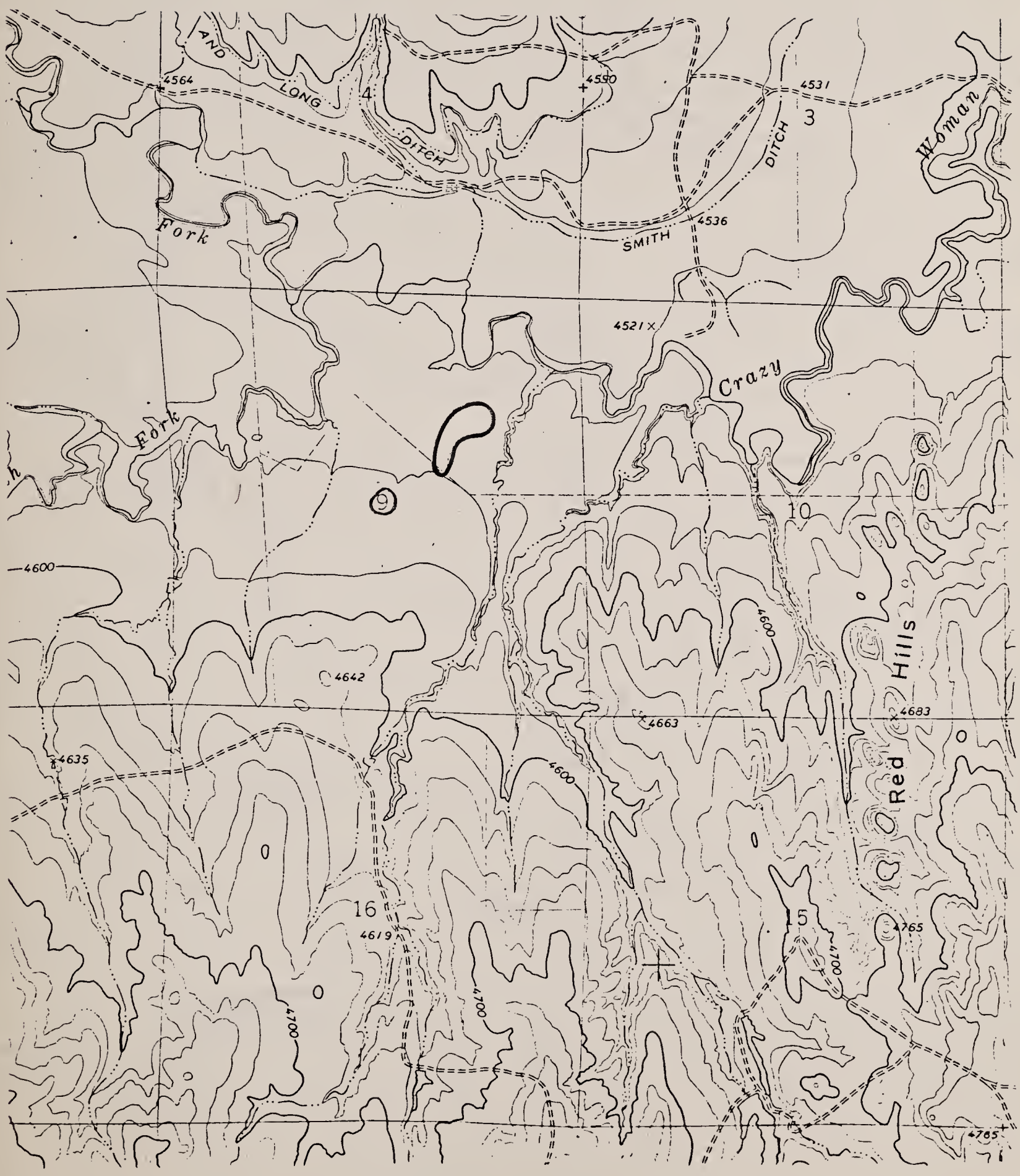
Kaycee / Pine Ridge Roost
(T44N R81W S22)

Deer Creek or Belle Fourche Roost
(T47N R70W S22)
(x = Roost trees)

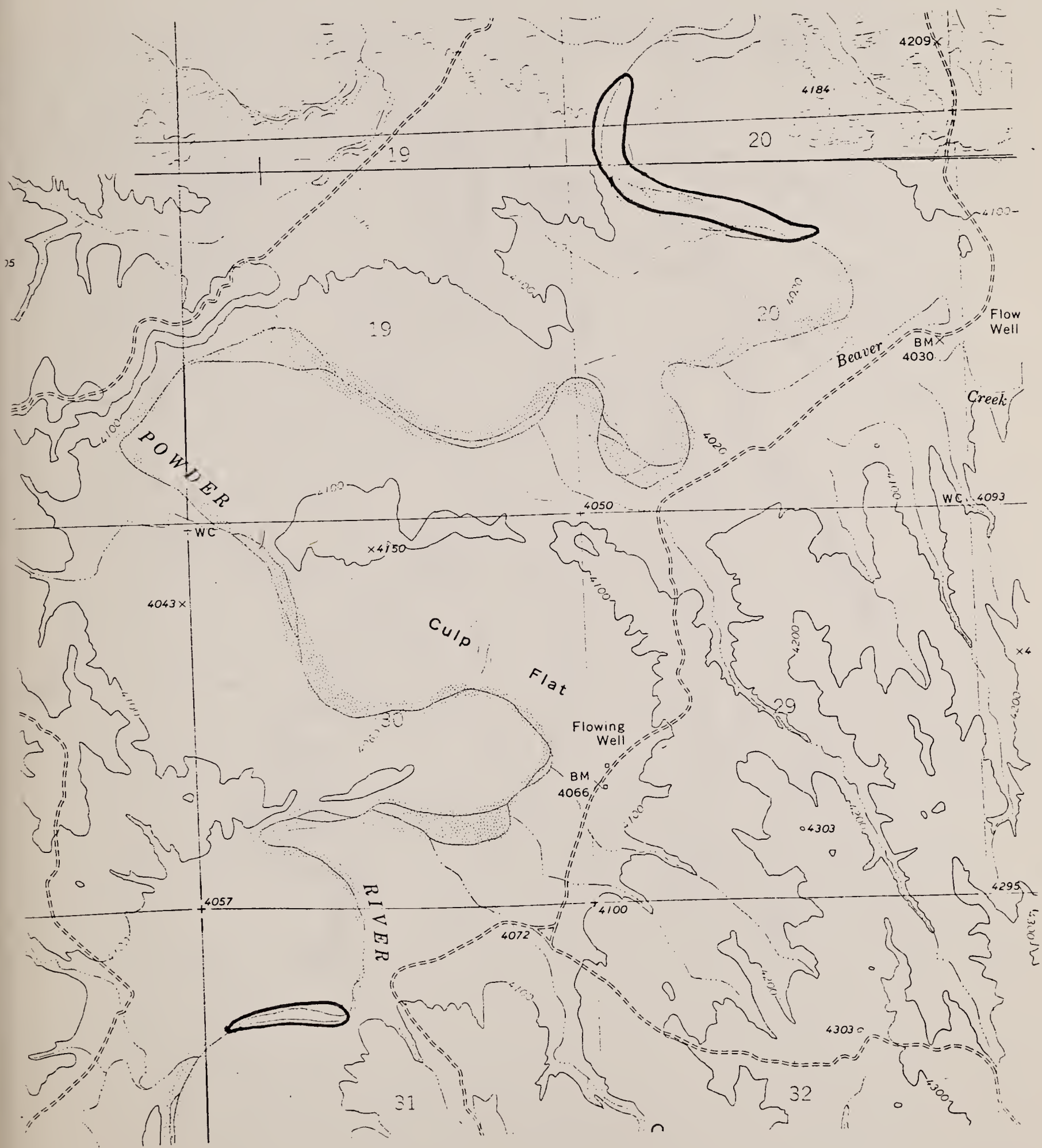
Powder River (Bowman Flat)
(T47N R78W S1,12)



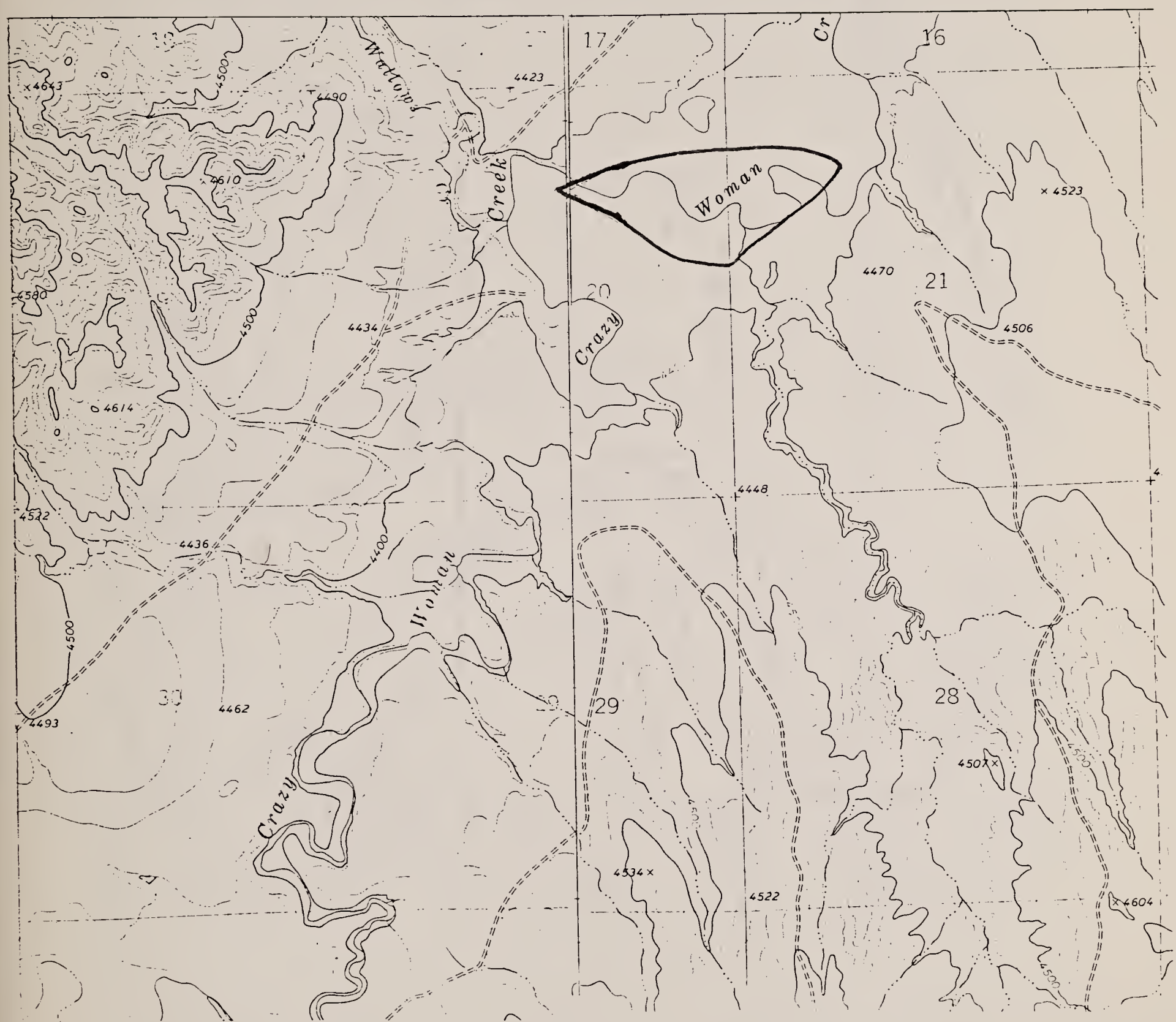
Crazy Woman Creek Roost West
(T47N R81W S9)



Powder River (Culp Flat)
(T48N R77W S31, T48N R77W S17,20)

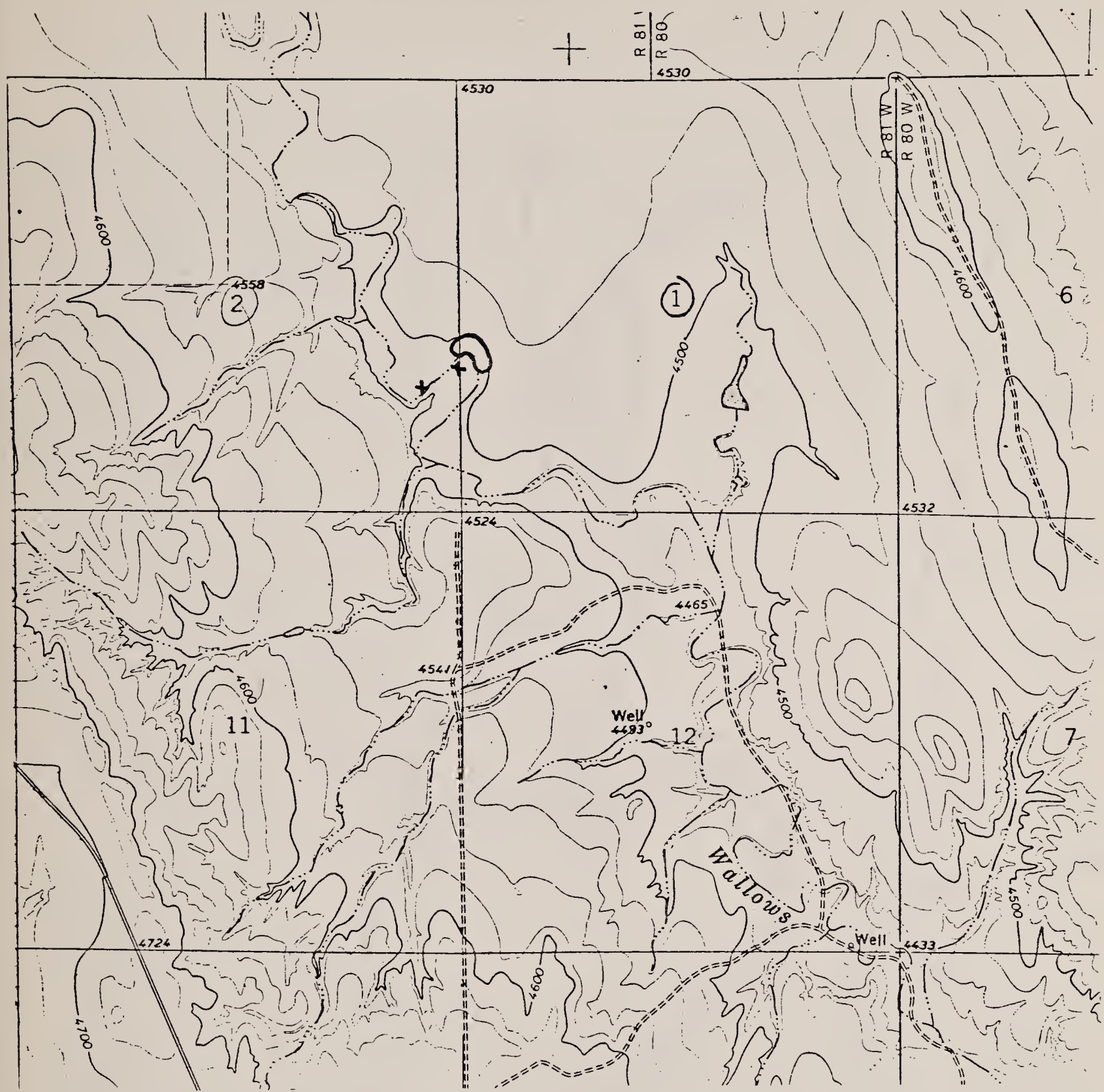


Crazy Woman (East)
(T48N R80W S20)

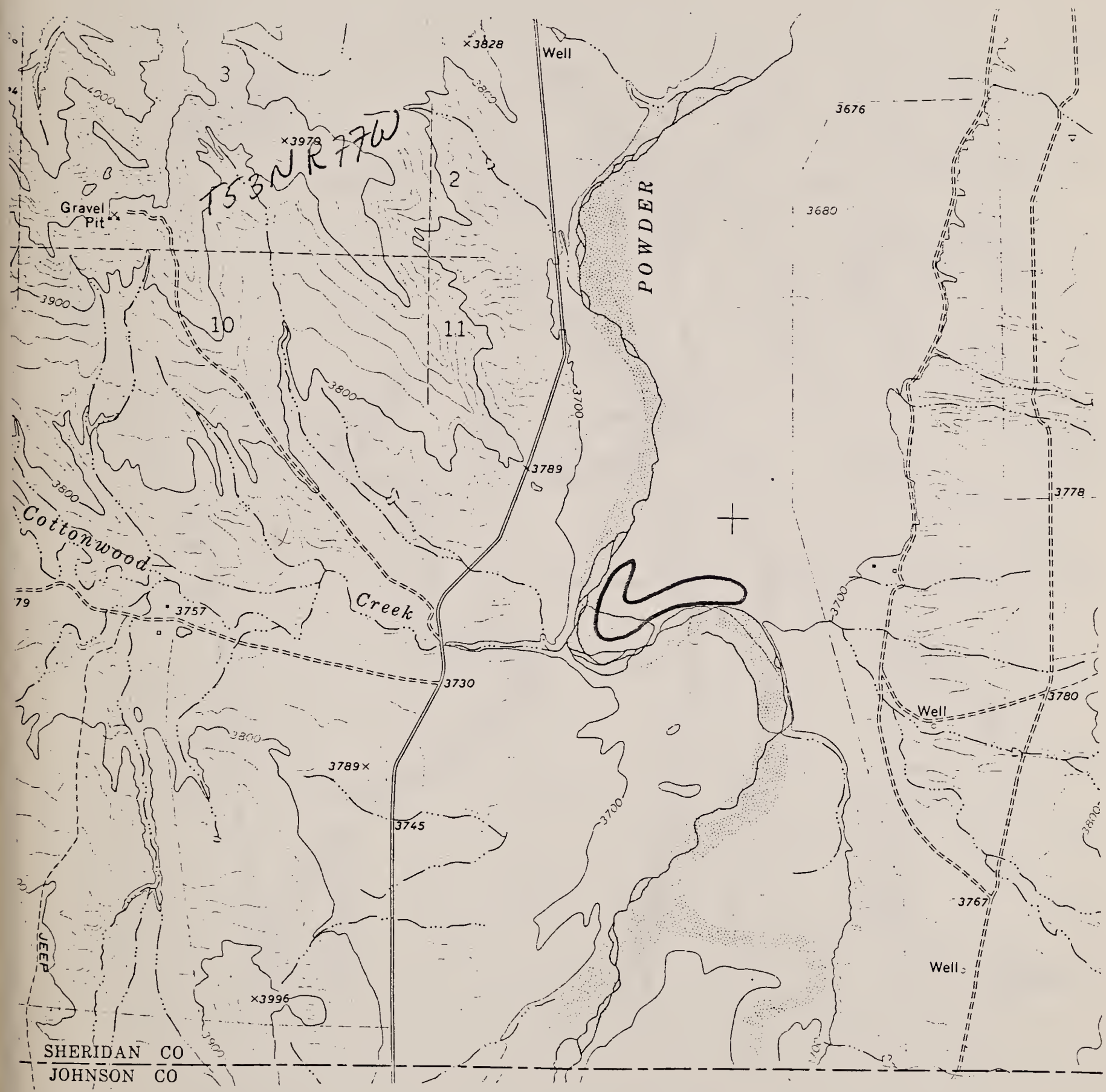


Wallow's Creek Roost

(T48N R81W S1)
(x = Roost trees)

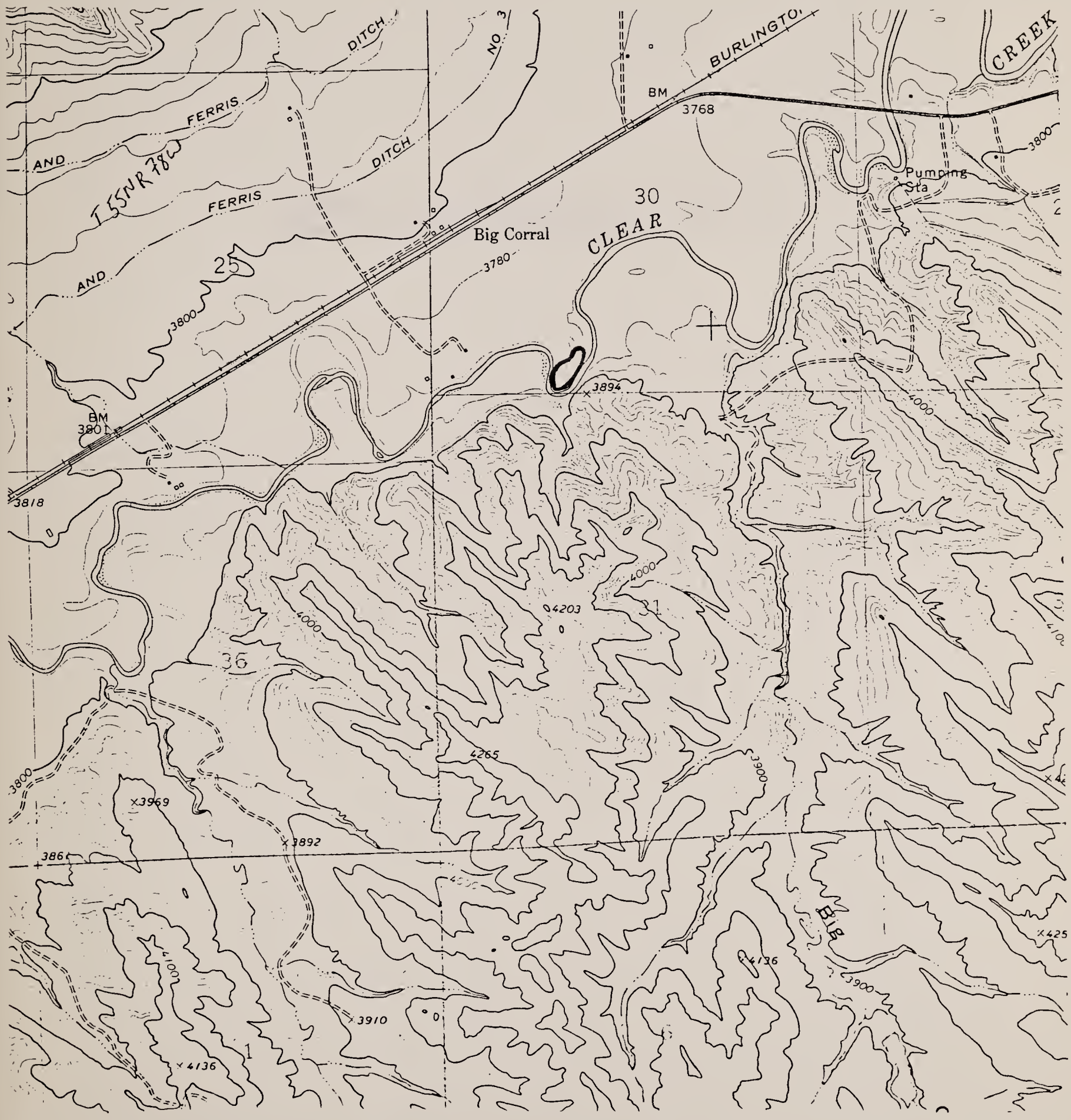


Powder River (Jones)South Roost
(T53N R77W S11)



Powder River (Jones) North Roost
(T54N R77W S36)

Clear Creek Roost
(T55N R78W S30)



Appendix B. Locations of Potential Roosts found in Northeastern Wyoming.

Table 1. Locations of potential sites of roosts.

Drainage	Legal Location	Source*
Deer Creek Canyon	T32N R77W S35**	This study
Hat Creek/Sage Creek	T34N R63W S6,S7	WGFD
Old Woman Creek	T37N R62W S2**	This study
South Fork Powder River	T37N R84W S27**	BLM
Wheatgrass Draw	T38N R62W S24	WGFD
Dry Fork Cheyenne River	T38N R71W S3 NW¼	USFWS, USFS
Teapot Dome	T38N R78W S5**	This study
	T39N R67W S18 W½, SW¼	USFWS
	T39N R68W S24 NE¼	USFWS
Dry Fork Cheyenne River	T39N R71W S25 SW¼**	USFWS
Antelope Creek	T40N R69W S8 NE¼, W½**	USFS
Antelope Creek	T40N R69W S13 NW¼**	USFS
	T41N R67W S25 N½, SW¼	USFS
	T41N R69W S1	USFS
	T41N R73W S25 NW¼, NW¼**	USFWS
	T42N R69W S5 E½, NW¼	USFS
Piney Creek	T42N R69W S25 SW¼, NE¼	USFWS
Middle Fork Powder River	T42N R84W S14**	Jenkens et al. (1981)
HA Creek	T43N R69W S10 SE¼	USFWS
	T43N R69W S15 W½, NW¼	USFS
	T43N R69W S16 SW¼	USFS, USFWS
Little Thunder Creek	T43N R70W S26 NW¼	USFS
Black Thunder Creek	T44N R69W S32**	USFWS

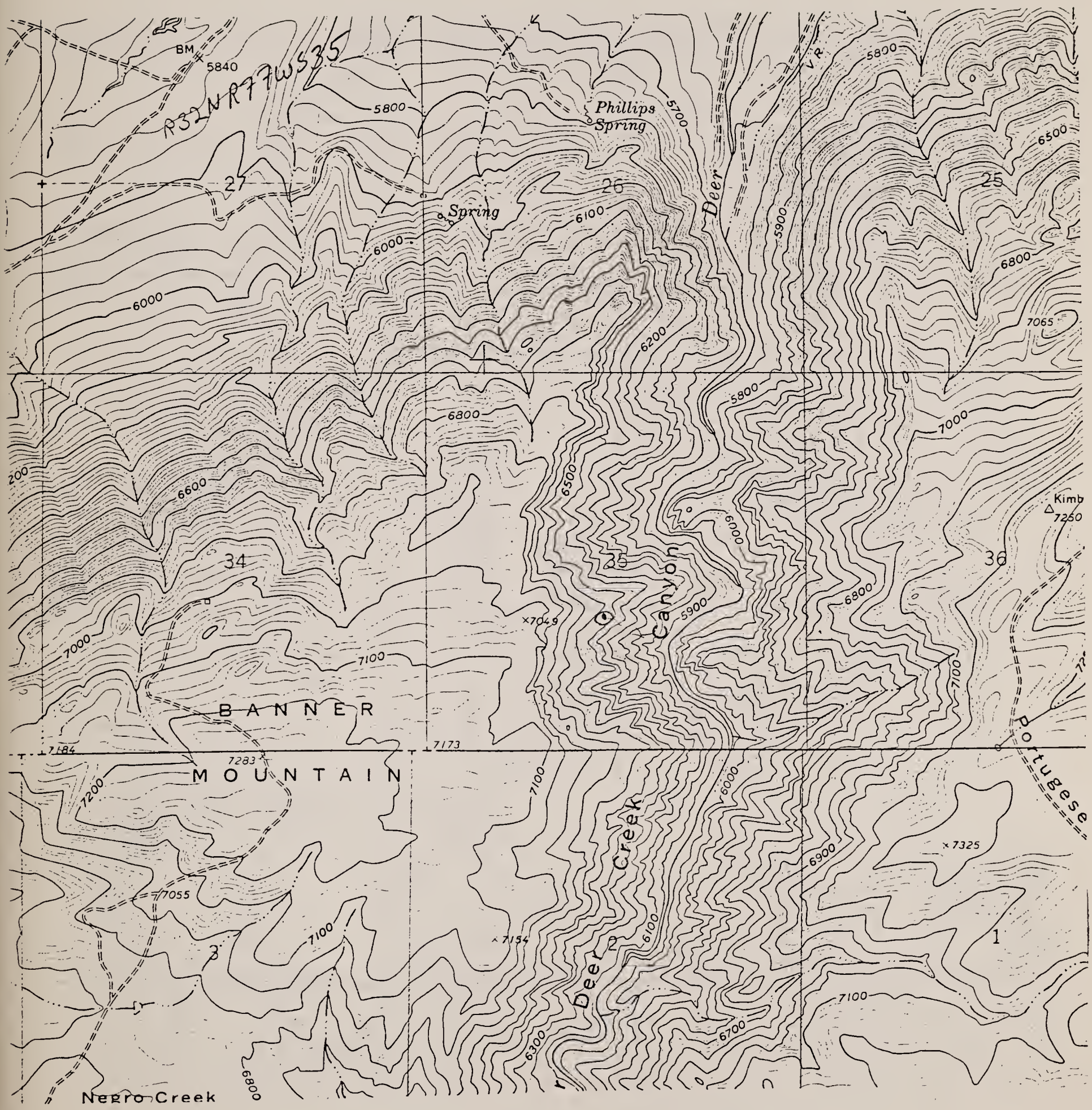
Table 1 continued.

Pumpkin Buttes	T44N R76W S15**	This study
	T52N R61W S3 SE¼, SW¼	WGFD

*USFS U.S. Forest Service
USFWS U.S. Fish and Wildlife Service
WGFD Wyoming Game and Fish Department

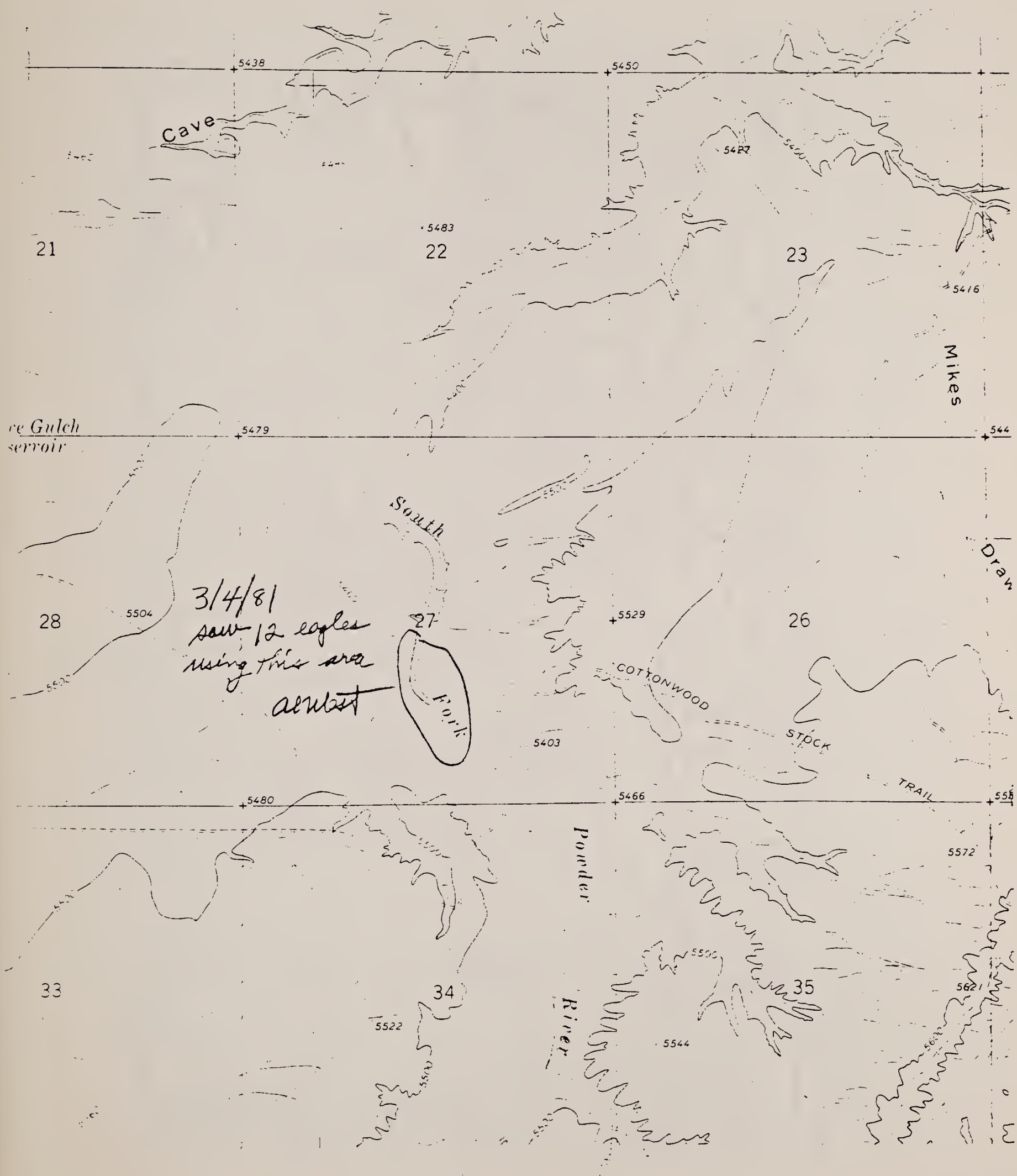
**Map of area provided

(T32N R77W S35)



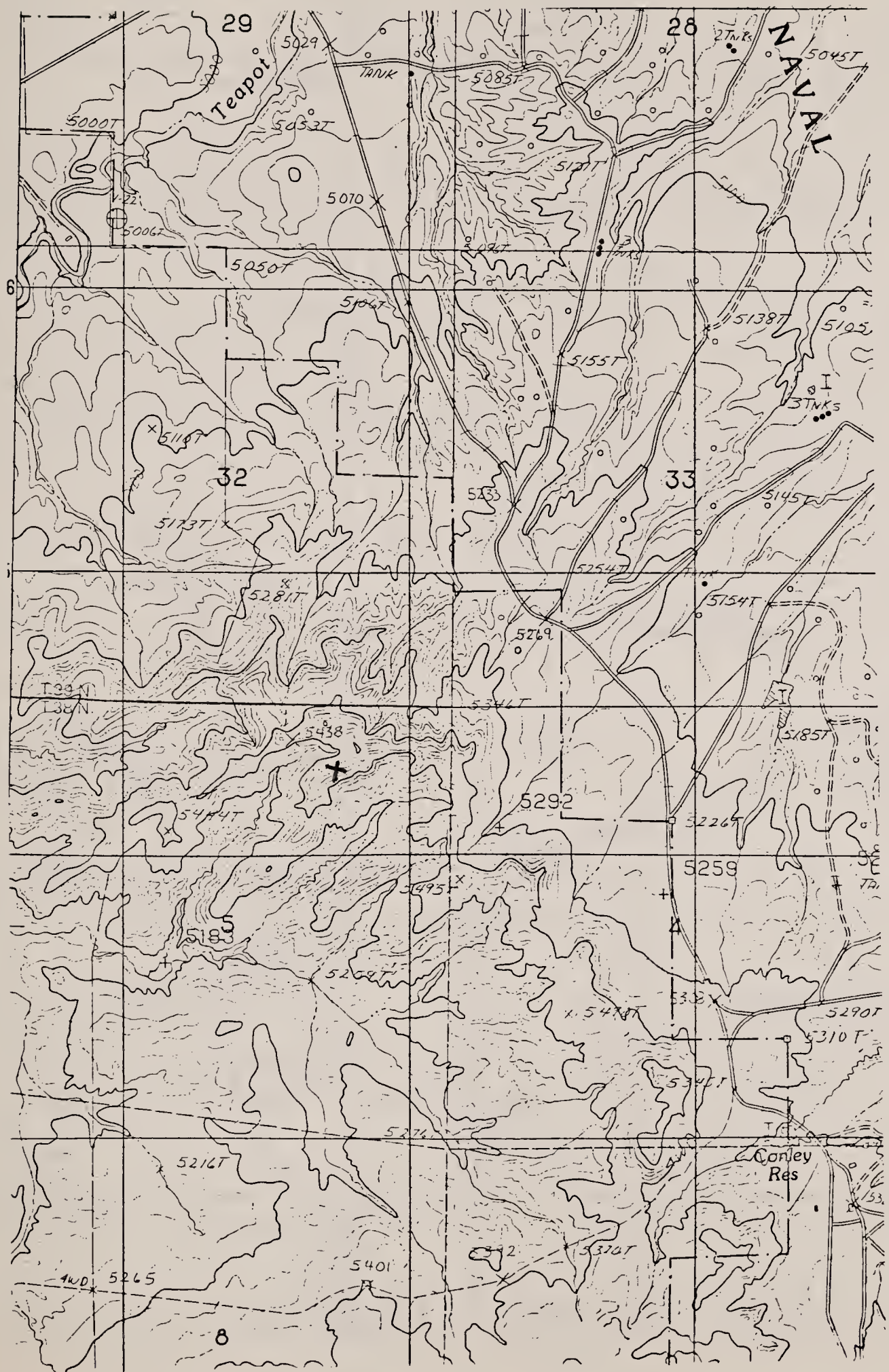
Old Woman Creek Roost
(T37 R62W S2)

(T37 R84W S27)
(BLM)



Teapot Dome Roost

(T38N R78W S5)



(T39N R71W S25 SW1/4)

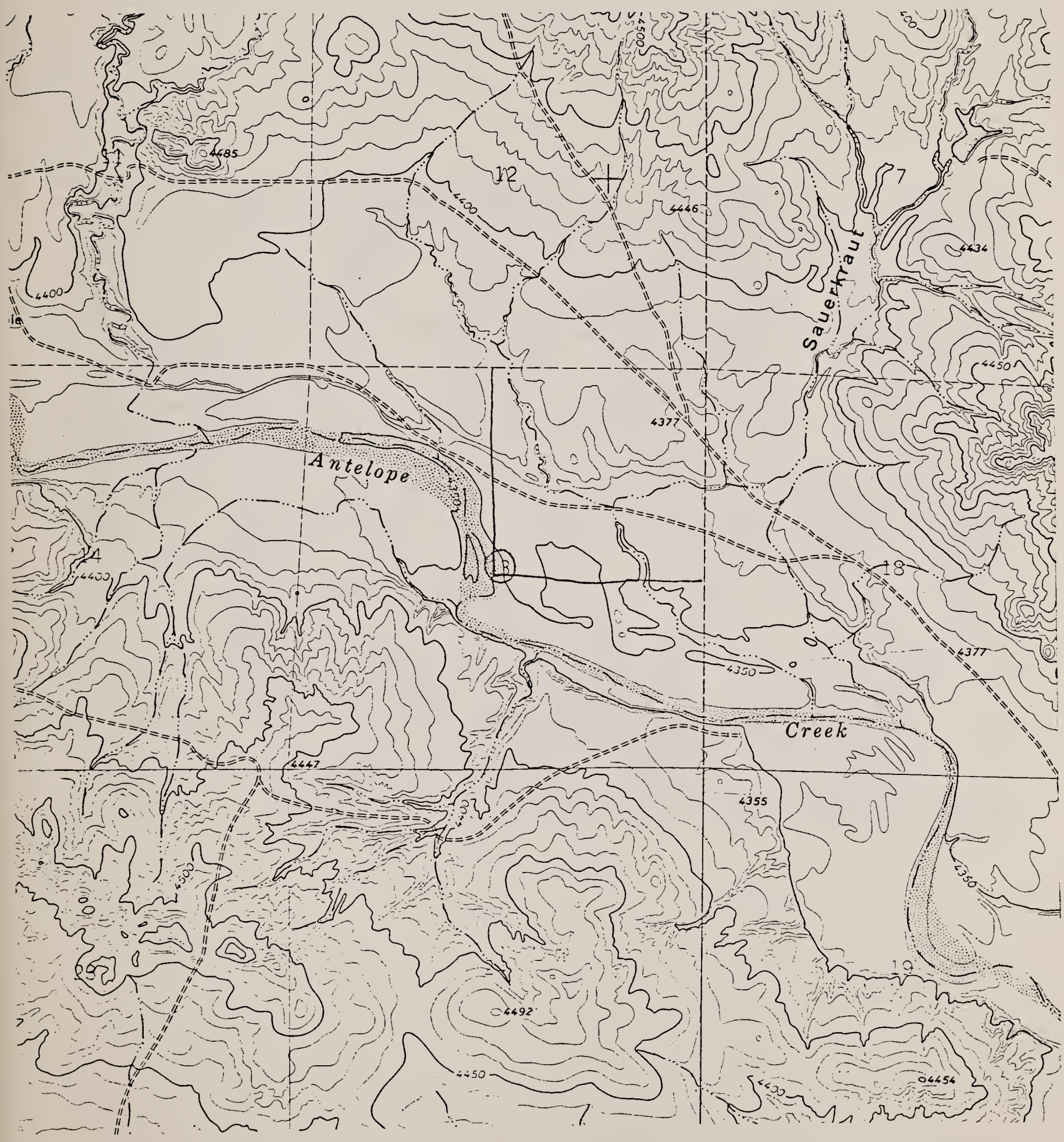
(Beske, Pers. Com. 1984)

(T40N R69W S8)

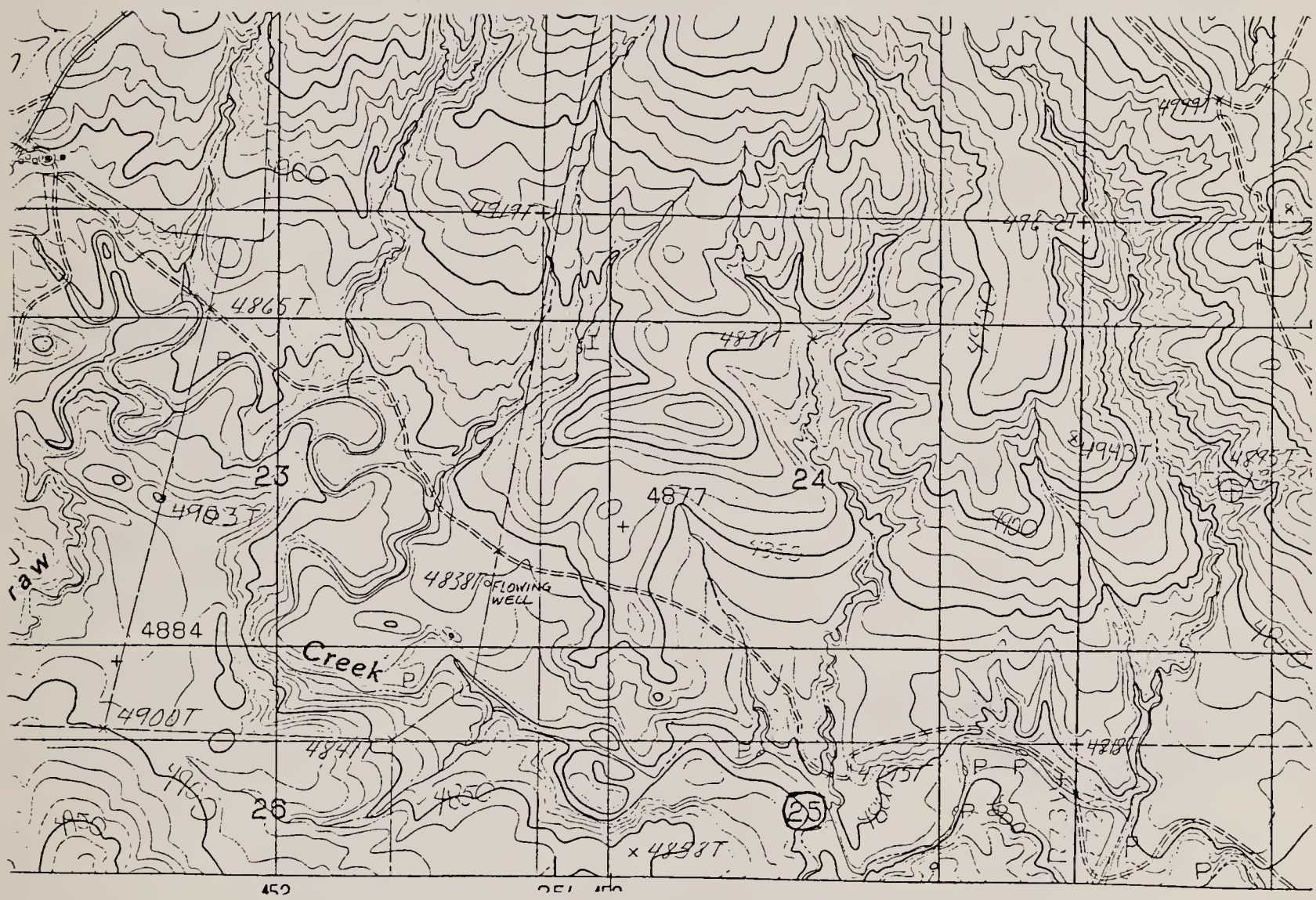
(USDA Forest Service)

(T40N R69W S13 NW1/4)

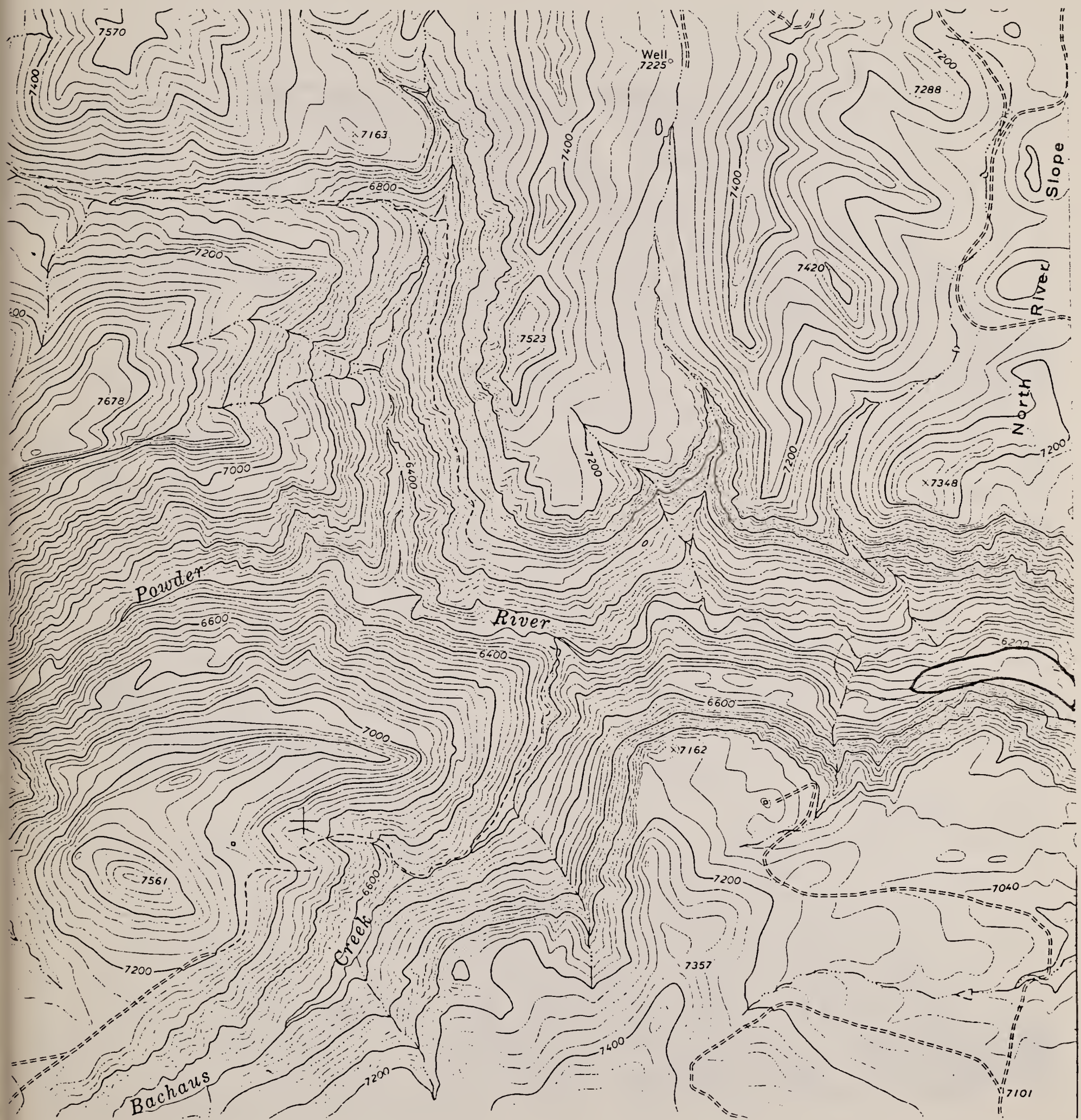
(USDA Forest Service)



(T41N R73W S25 NW1/4 NW1/4)
(Beske, Pers. Com. 1984)

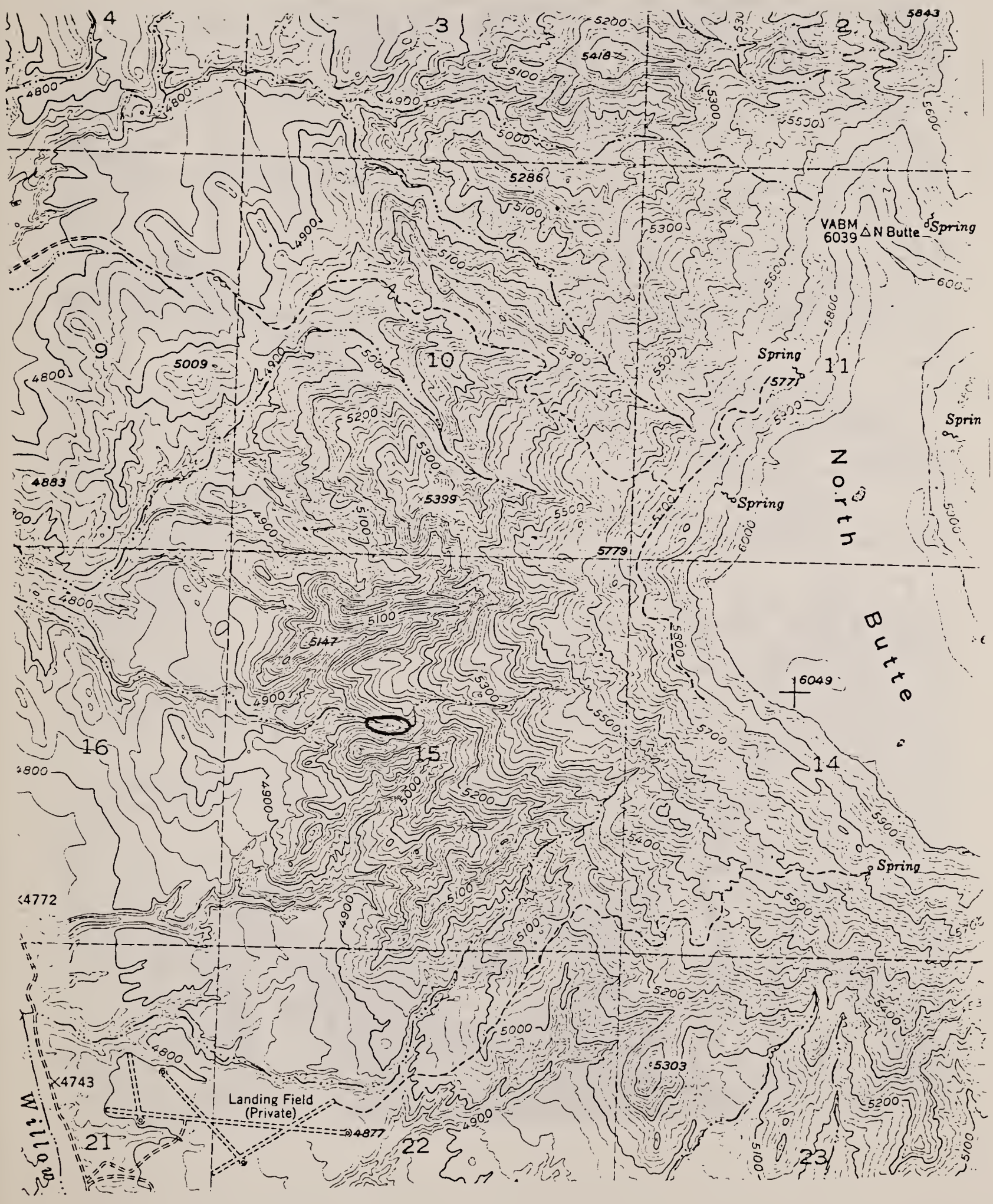


Powder River (Middle Fork)
(T42N R84W S14)
(From Jenkins et al. 1980)



Black Thunder Creek Roost
(T44N R69W S32)
(U.S.D.I. Fish and Wildlife Service 1985)

Pumpkin Buttes Roost
(T44N R76W S15)



(T52N R61W S3 SE1/4 SW1/4)
(Wyoming Game Fish Department 1984)

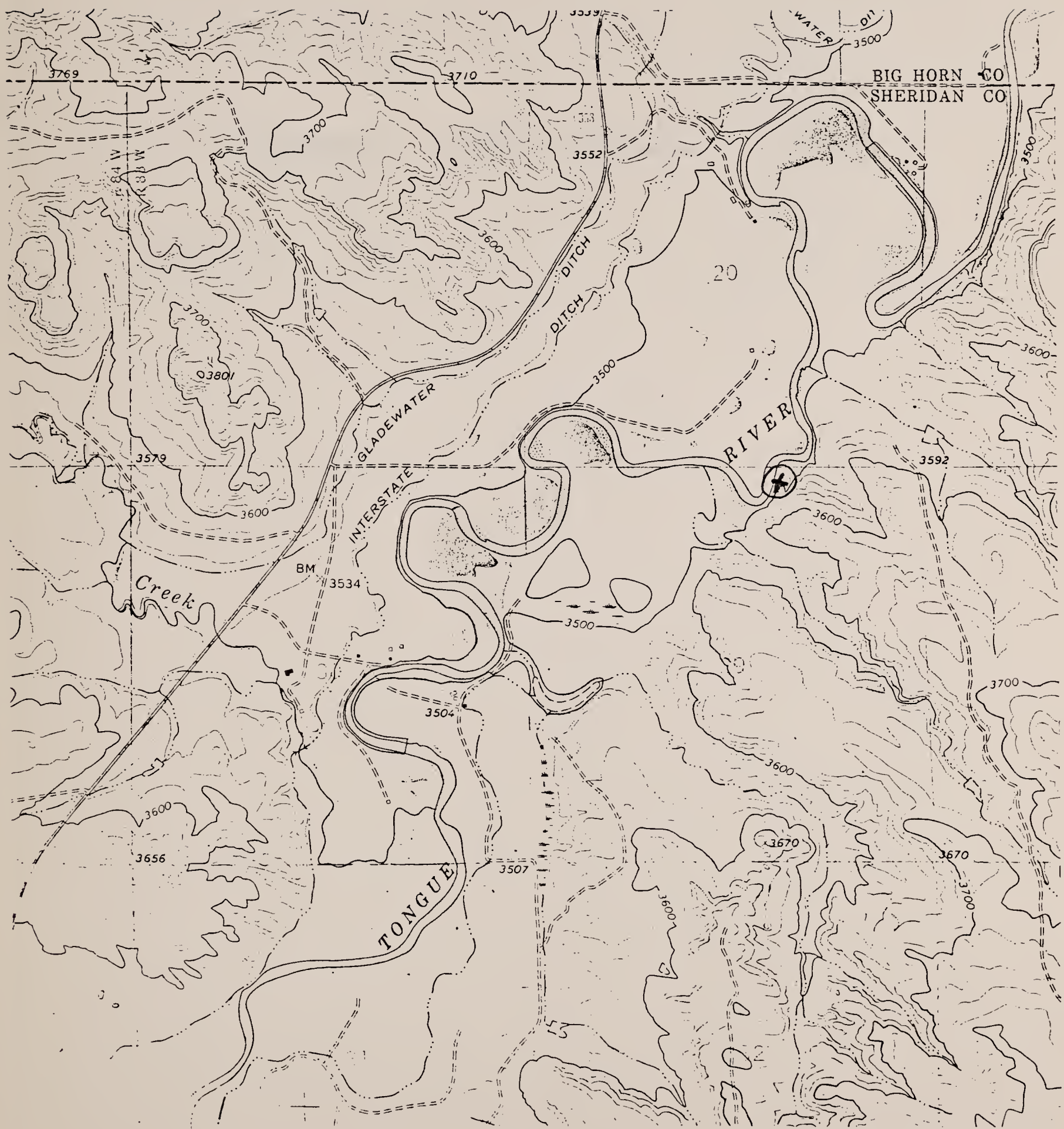
Appendix C. Locations of Nests of Bald Eagles.

Bald Eagle Nest

(T56N R79W S25)

Bald Eagle Nest, Tongue River

(T58N R83W S29)



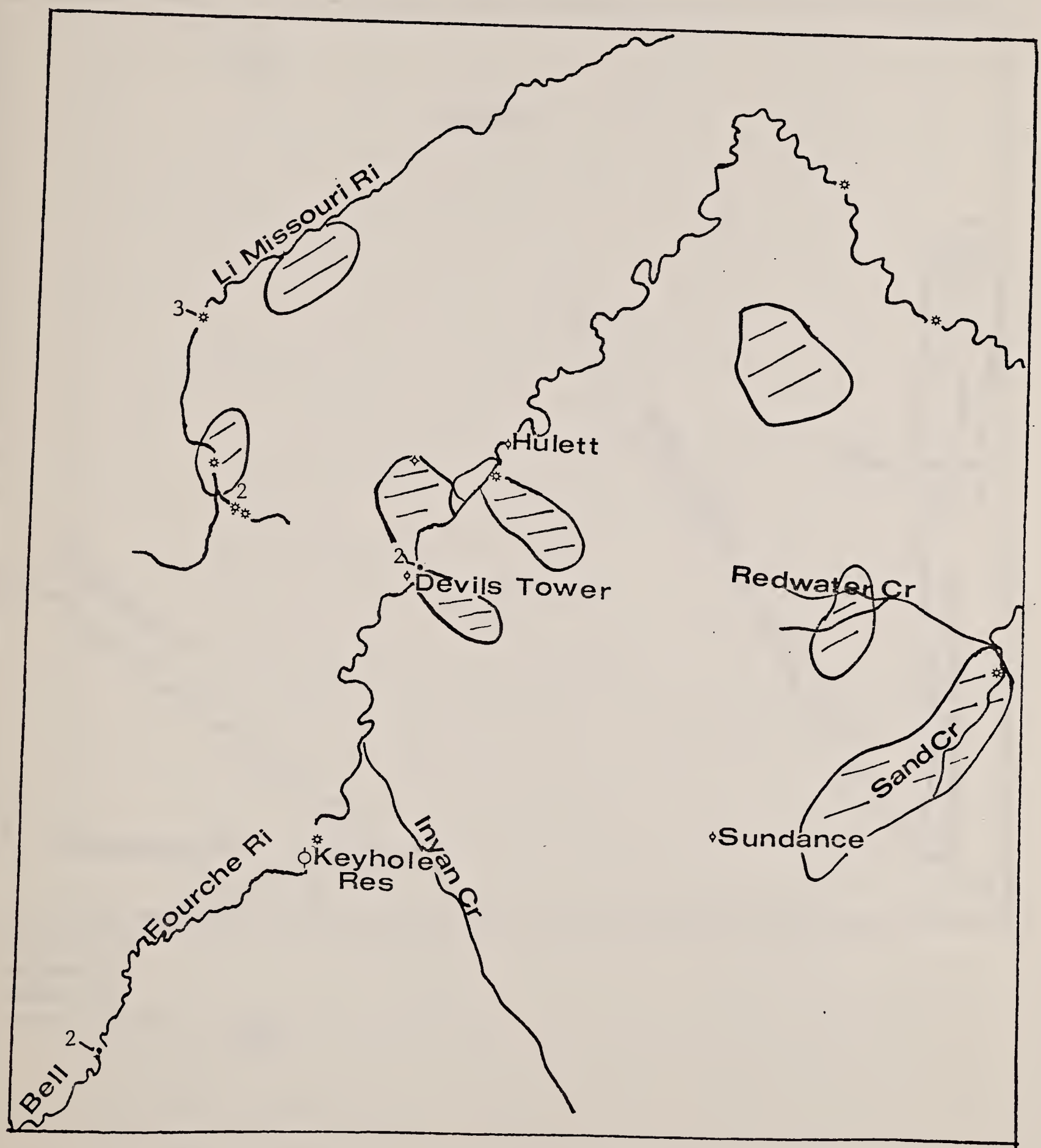
Appendix D. Locations of Heronries.

Table I. Locations of Heronries recorded during aerial surveys.

River	Legal Location
Bates Creek	T30N R79W S29 or 32
Bell Fource/Keyhole Reservoir	T50N R67W S8 or 9
Clear Creek	T53N R80W S30
	T55N R78W S20,21
	T56N R77W S10 or 2
Crazy Woman Creek	T47N R81W S9
	T48N R80W S29
	T48N R80W S31
	T50N R79W S7
Lake De Smet	T52N R82W S7 or 8
Little Powder River	T55N R71W S23
North Platte River	T31N R69W S22,27
	T33N R76W S4
	T33N R77W S5,6
Piney Creek	T53N R81W S10
Powder River	T54N R77W S36
	T56N R77W S24 or 25

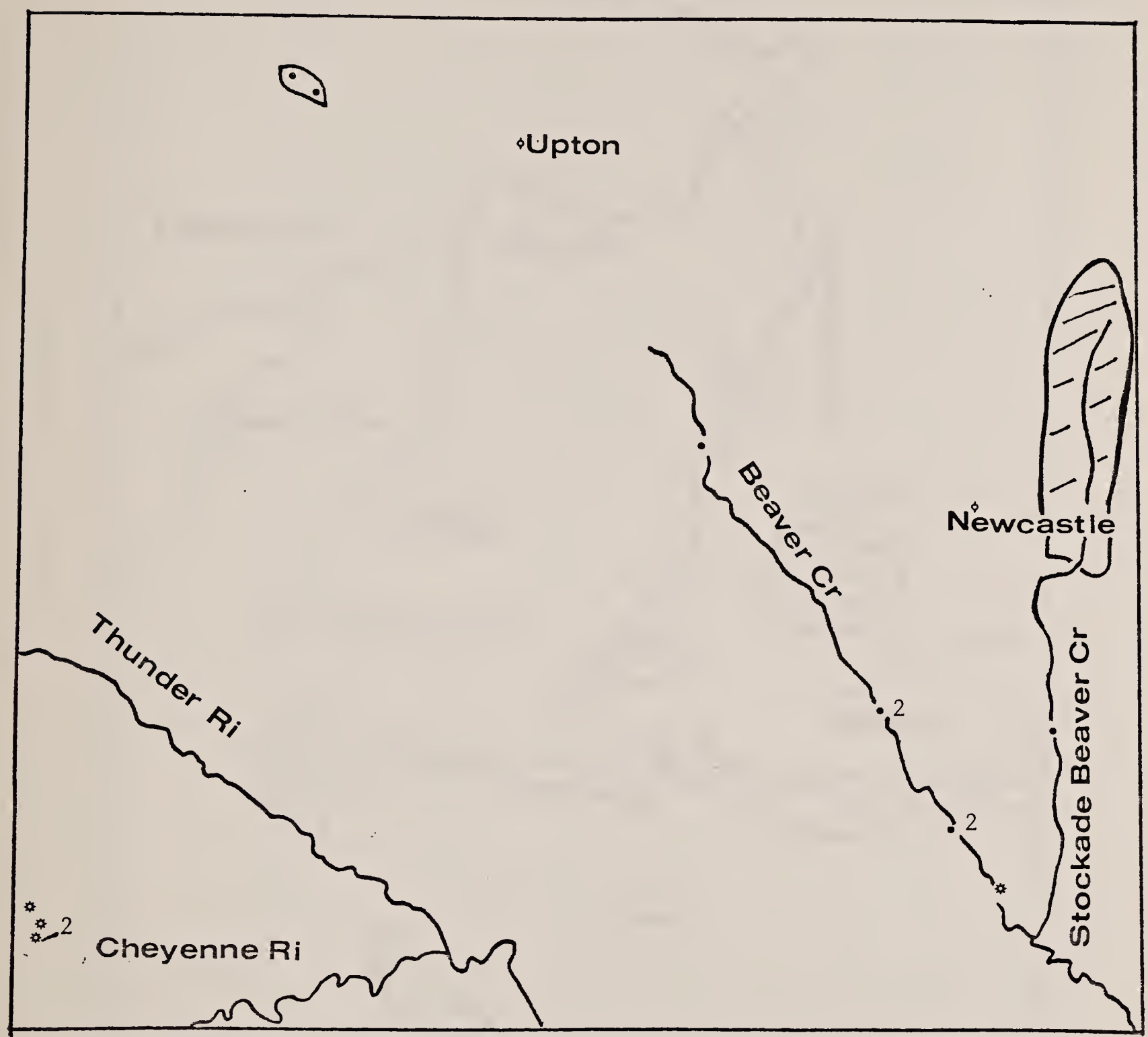
Appendix E. Areas surveyed and locations of eagles observed during aerial surveys.

Figure 1. Areas searched, rivers flown, and eagles observed during aerial surveys in January and February 1985 in Crook County,Wy. Sample sizes are provided where more than 1 eagle was observed.



Adult Bald = ✲
Immature Bald = ✧
Golden = •
Towns = ◊
Areas surveyed =

Figure 2. Areas searched, rivers flown, and eagles observed during aerial surveys in January and February 1985 in Weston County, Wy. Sample sizes are provided where more than 1 eagle was observed.



Adult Bald = ✡
Golden = •
Towns = ◊
Areas Surveyed =

Figure 3. Areas searched, rivers flown, and eagles observed during aerial surveys in January and February 1985 in Niobrara County, Wy. Sample sizes are provided where more than 1 eagle was observed.

Adult Bald = ✲
Adult Bald, Golden = ●
Adult Bald, Immature = ☼
Golden = •
Immature Bald = ✧
Towns = ◊
Areas Surveyed = ═══

Figure 4. Areas searched, rivers flown, and eagles observed during aerial surveys in January and February 1985 in Goshen County, Wy. Sample sizes are provided where more than 1 eagle was observed.

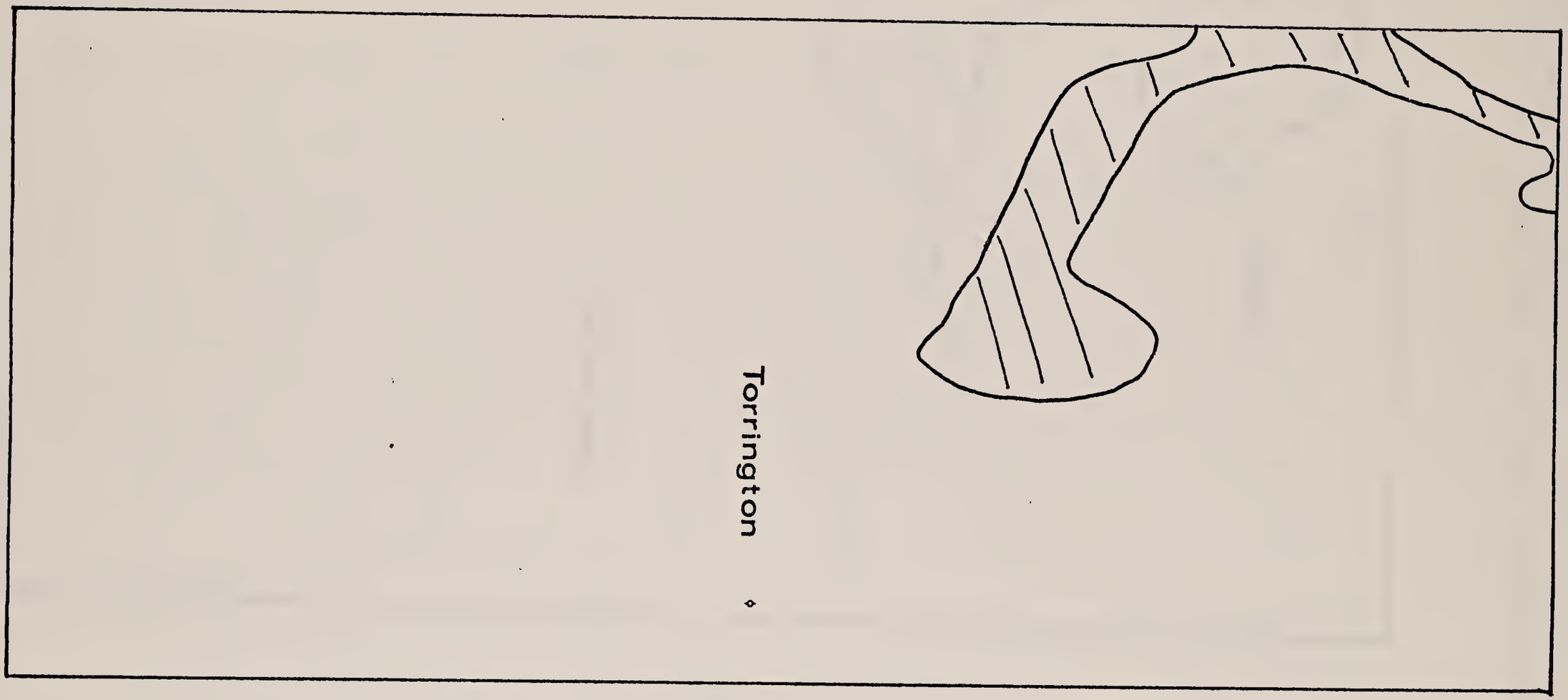


Figure 5. Areas searched, rivers flown, and eagles observed during aerial surveys in January and February 1985 in Platte County, Wy. Sample sizes are provided where more than 1 eagle was observed.

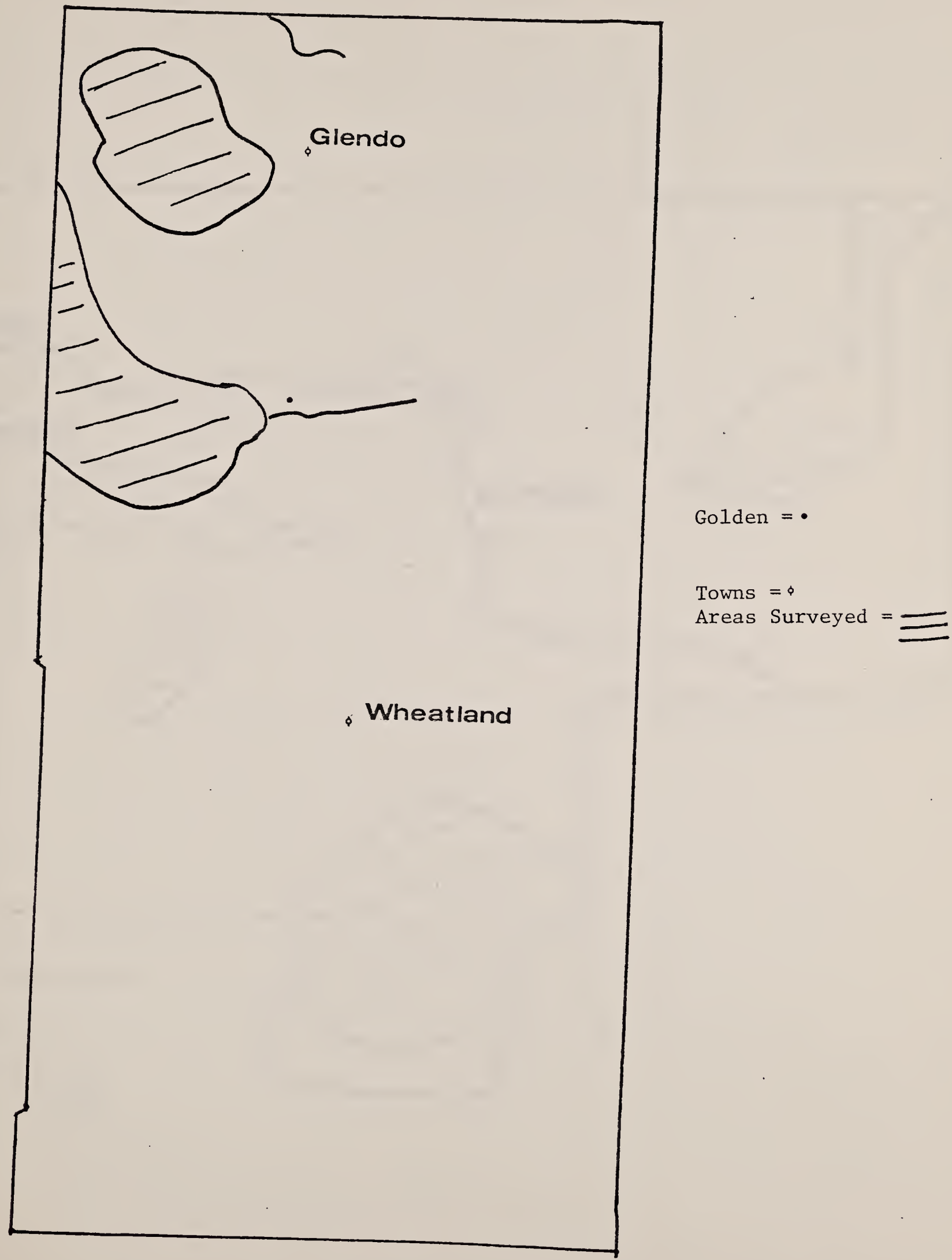


Figure 6. Areas searched, rivers flown, and eagles observed during aerial surveys in January and February 1985 in Converse County, Wy. Sample sizes are provided where more than 1 eagle was observed.

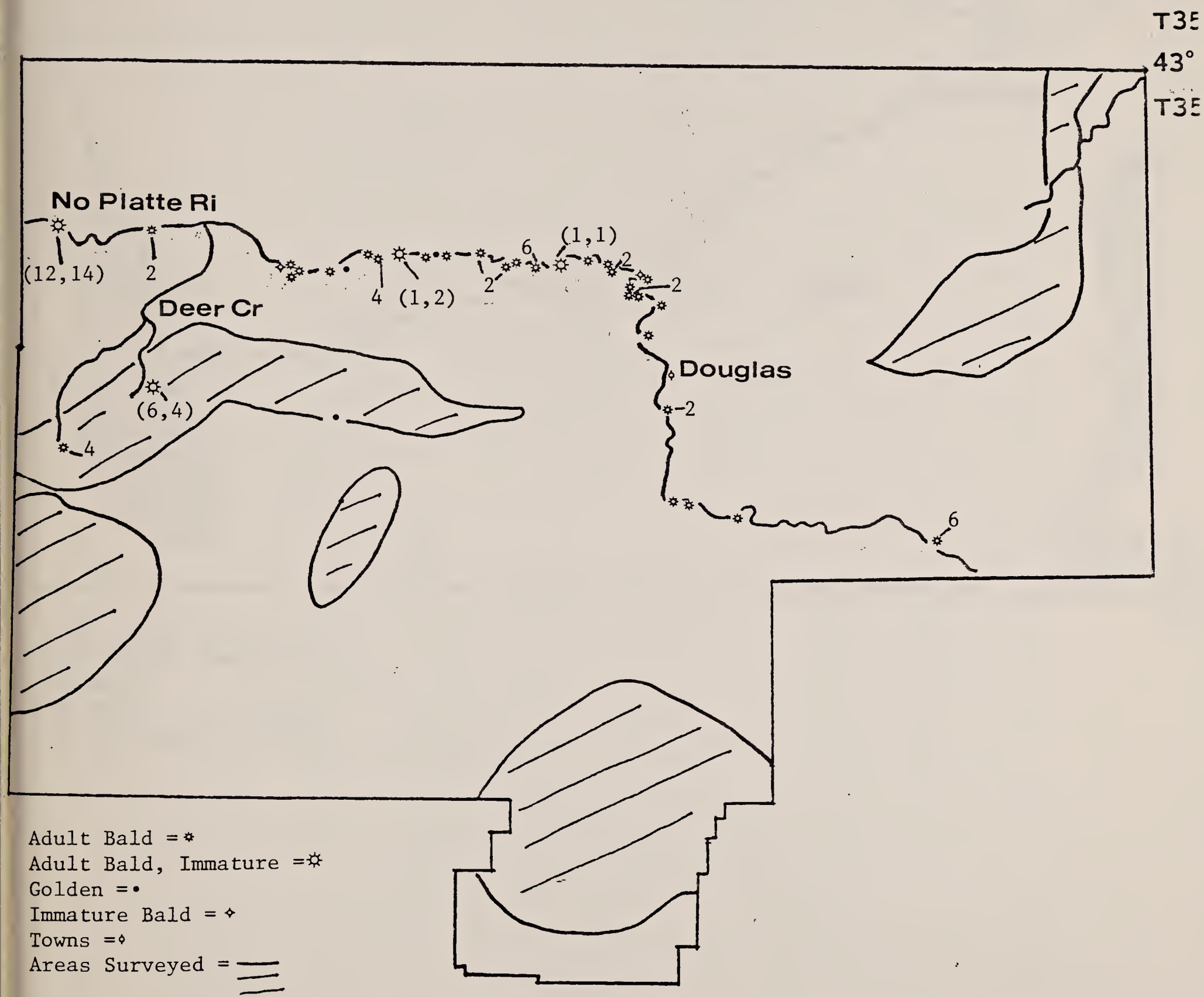
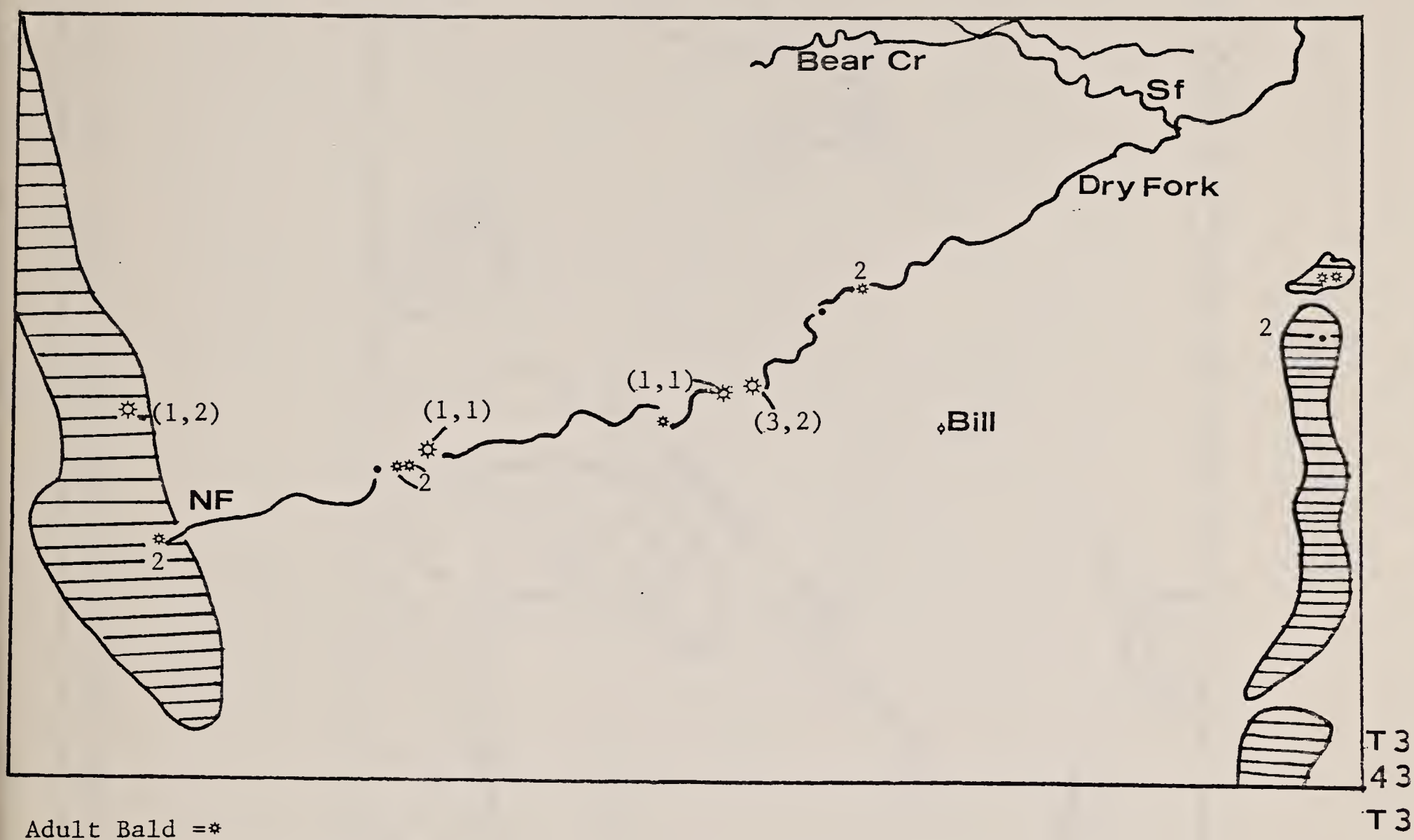


Figure 6. Con't.



Adult Bald =✲
Adult Bald, Immature =✧
Golden =•
Towns = ◊
Areas Surveyed =

Figure 7. Areas surveyed, rivers flown, and eagles observed during aerial surveys in January and February 1985 in Natrona County, Wy. Sample sizes are provided where more than 1 eagle was observed.

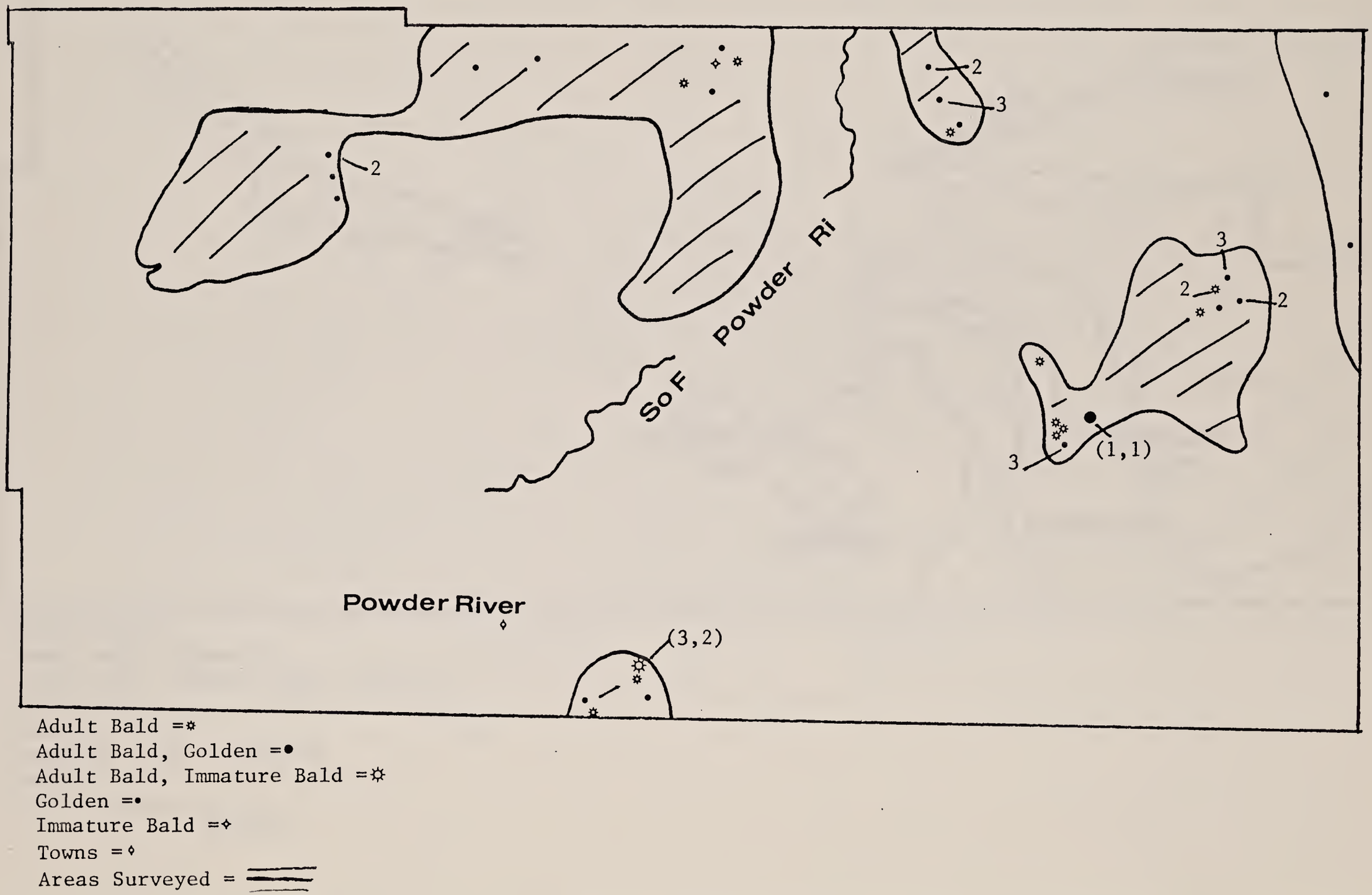
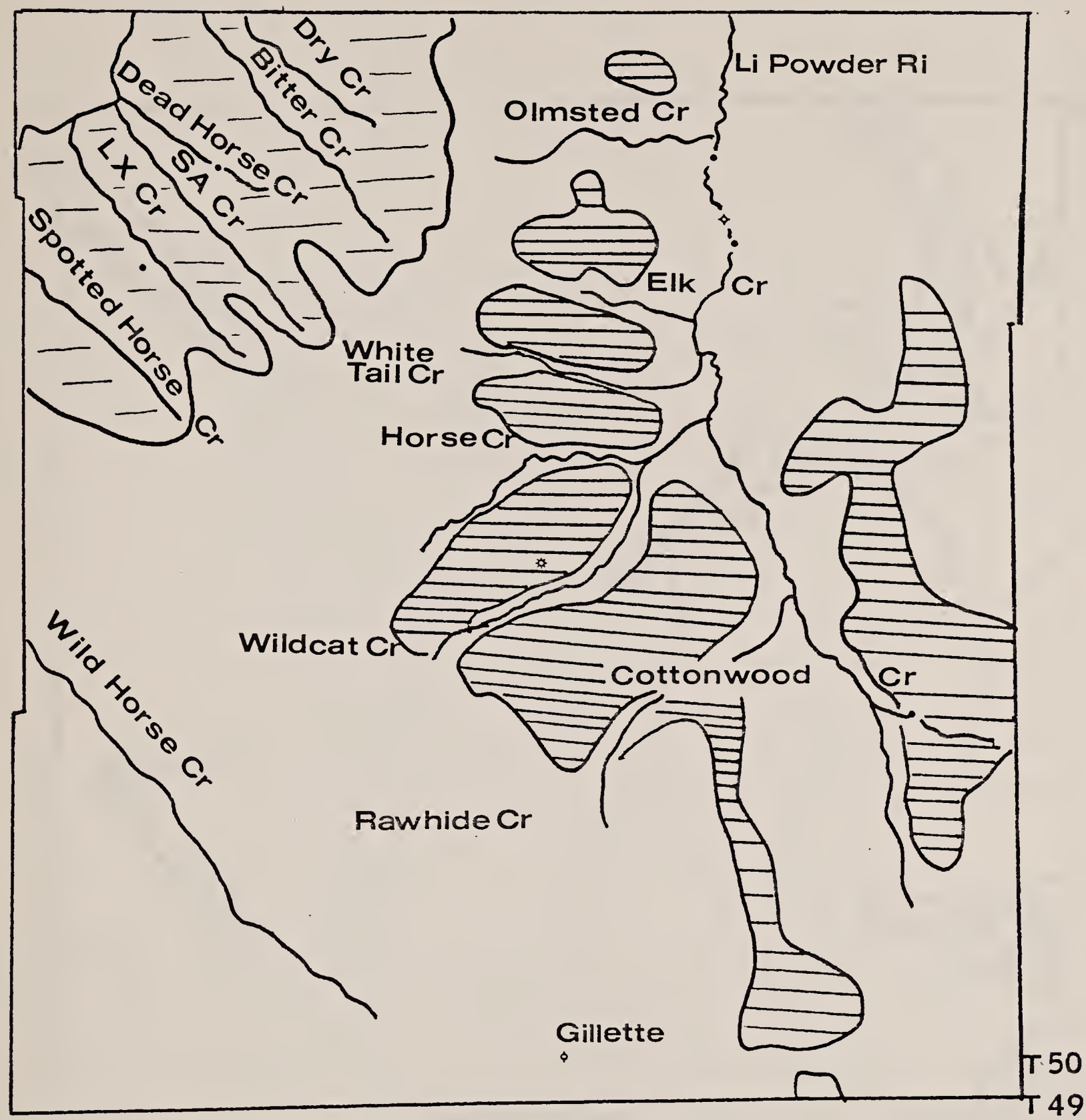


Figure 7. Con't.

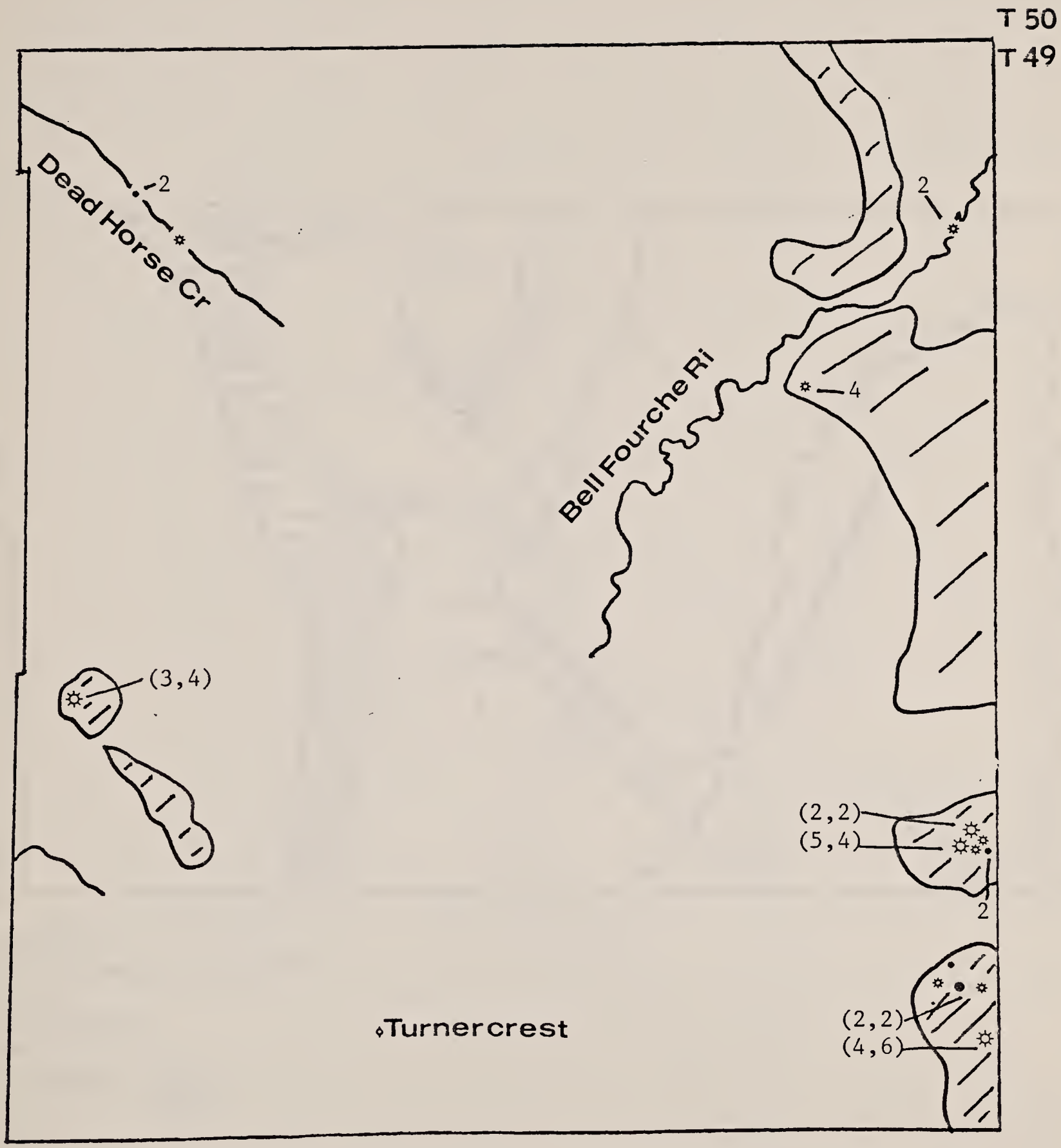
Adult Bald =✲
Adult Bald, Golden =●
Adult Bald, Immature Bald, Golden =✧
Golden =•
Immature Bald =✧
Immature Bald, Golden =✦
Towns =◊
Area Surveyed ═══

Figure 8. Areas surveyed, rivers flown, and eagles observed during aerial surveys in January and February 1985 in Campbell County, Wy. Sample sizes are provided where more than 1 eagle was observed.



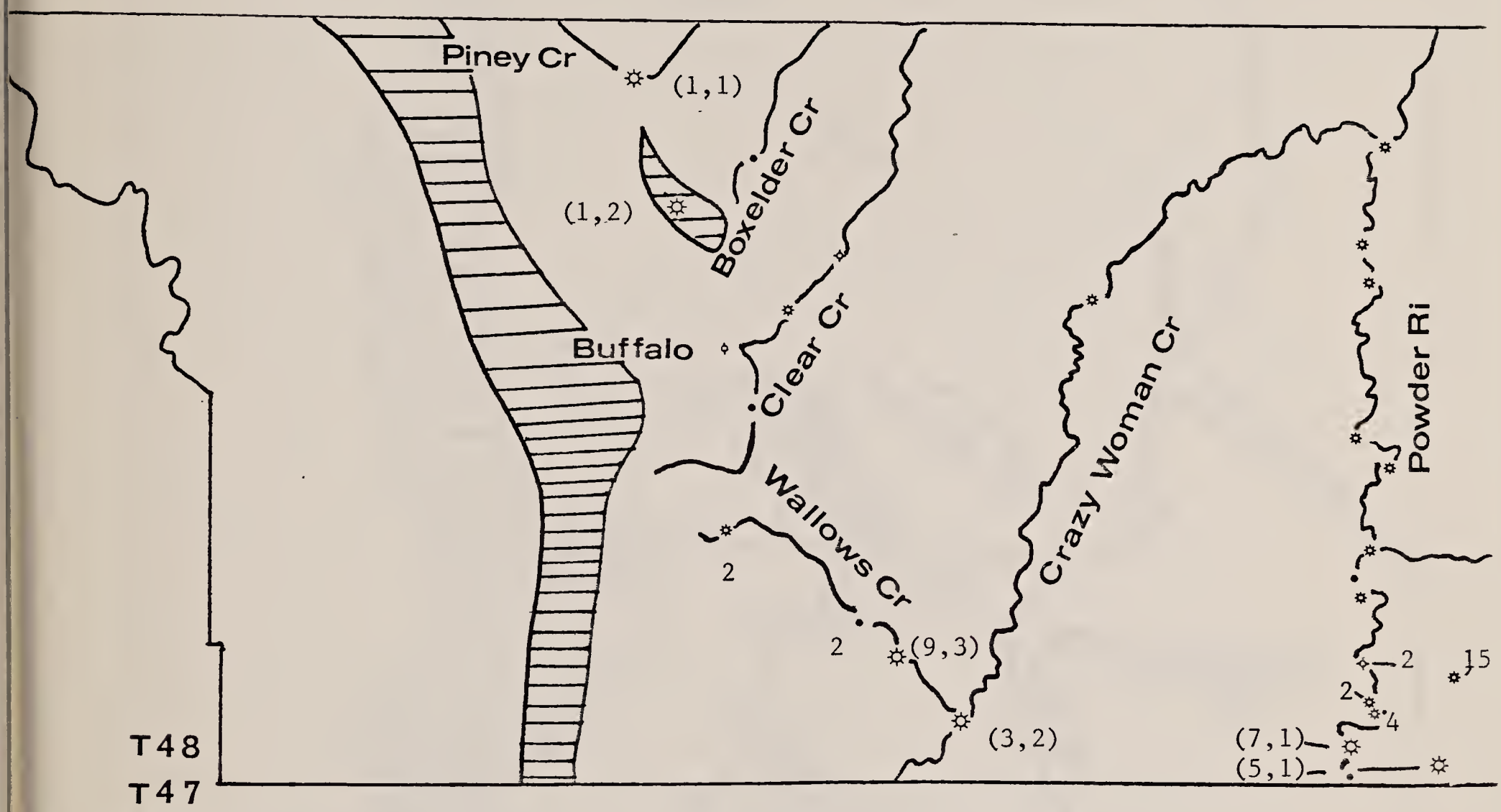
Adult Bald = ✲
Golden = •
Immature Bald = ✧
Towns = ◊
Areas Surveyed =

Figure 8. Con't.



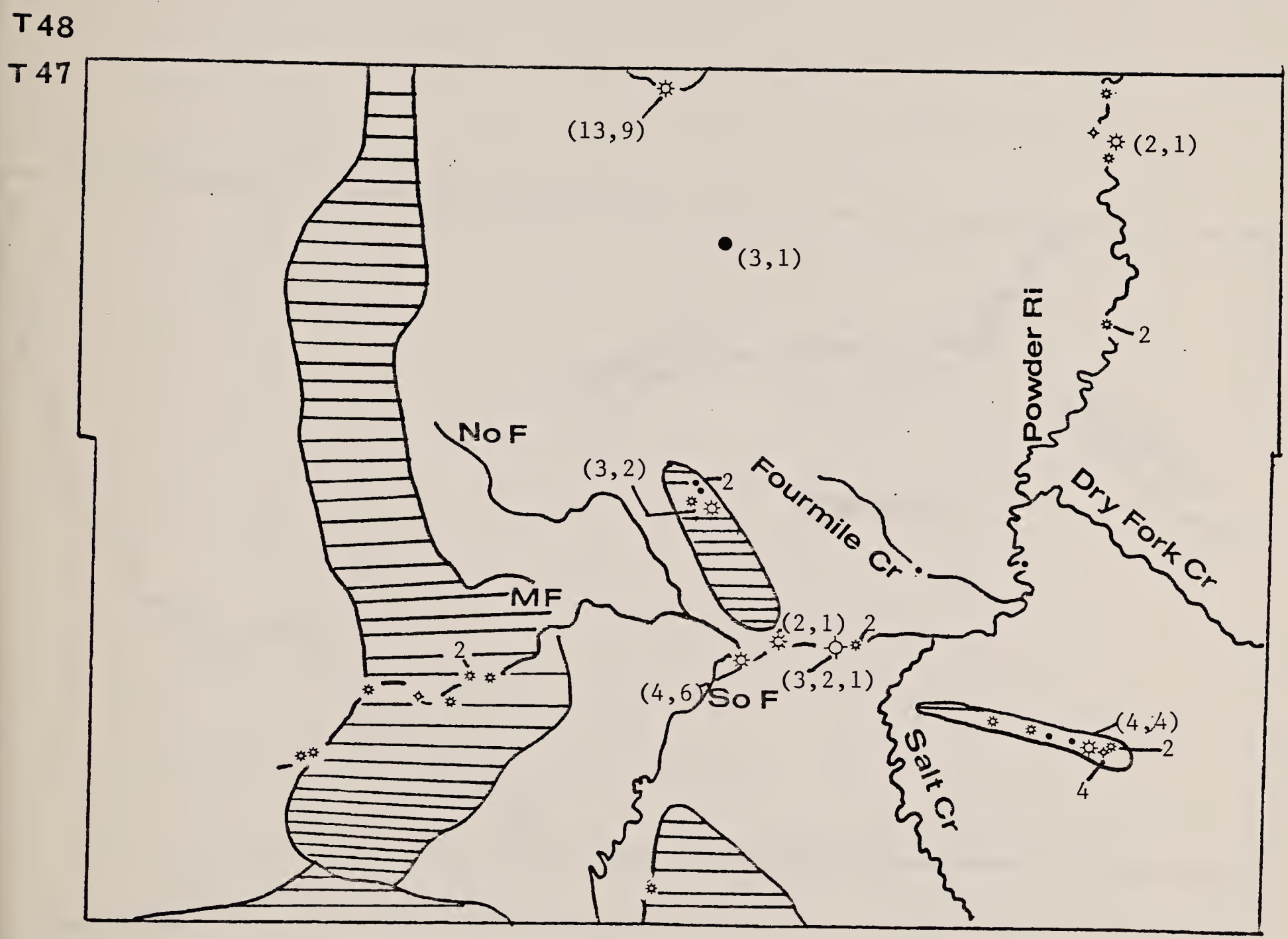
Adult Bald = ✲
Adult Bald, Golden = ●
Adult Bald, Immature = ☼
Golden = •
Towns = ◊
Areas Surveyed =

Figure 9. Areas searched, rivers flown, and eagles observed during aerial surveys in January and February 1985 in Johnson County, Wy. Sample sizes are provided where more than 1 eagle was observed.



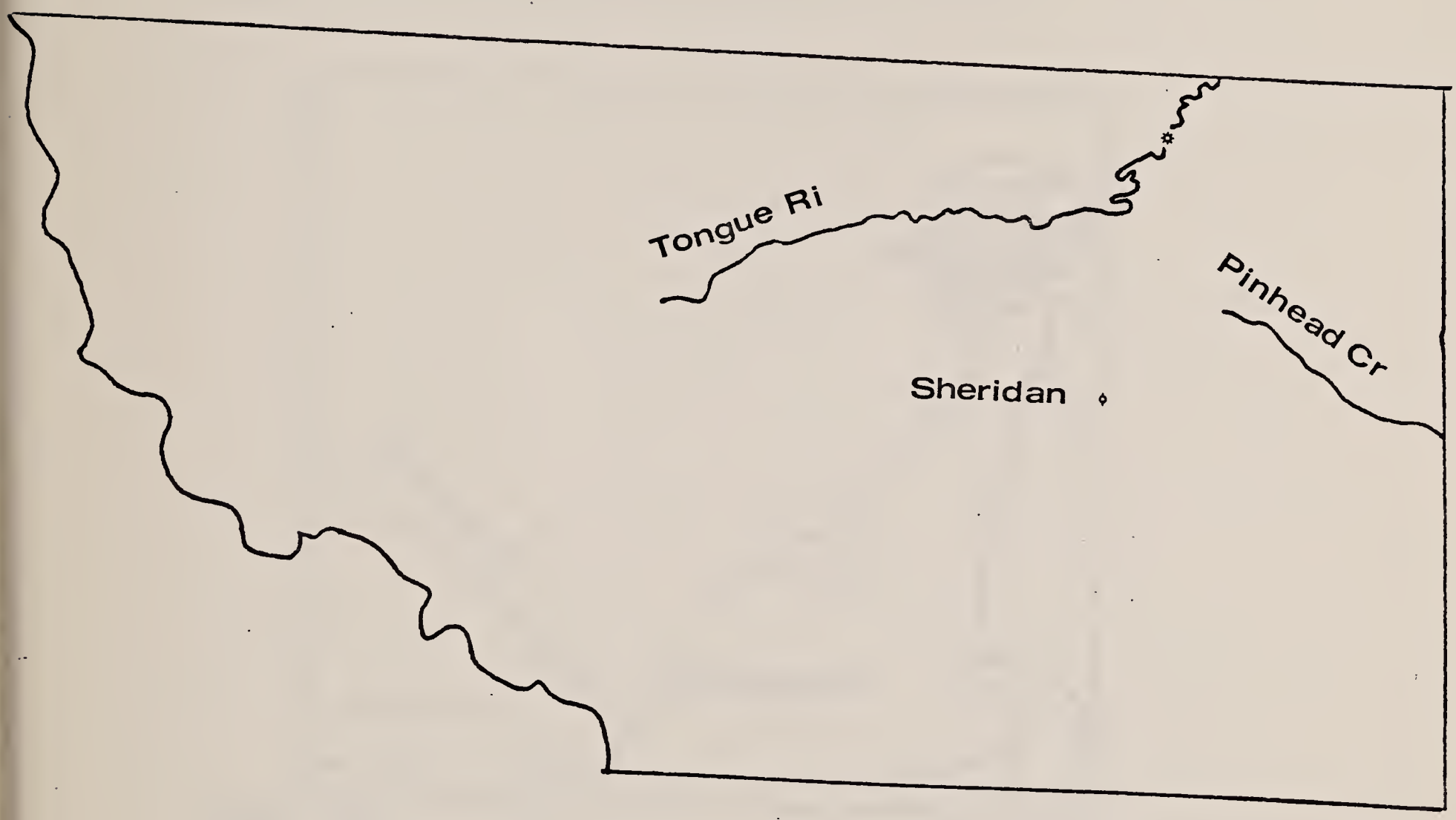
Adult Bald =✲
Adult Bald, Immature Bald =☼
Golden =•
Immature Bald =✧
Towns =◊
Areas Surveyed =

Figure 9. Con't.



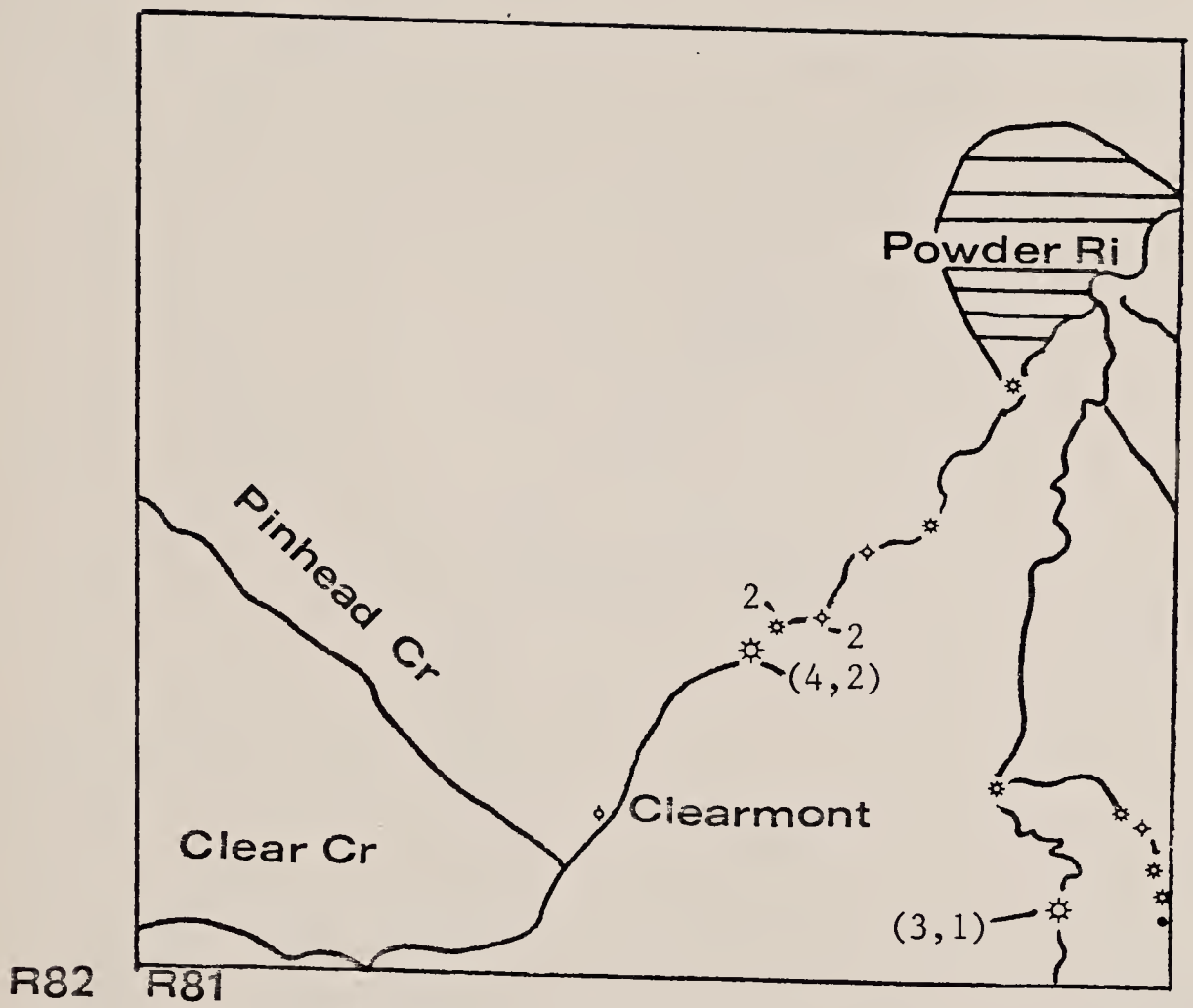
Adult Bald = ✲
Adult Bald, Golden = ●
Adult Bald, Immature = ☼
Golden = •
Immature = ✧
Areas Surveyed =

Figure 10. Areas searched, rivers flown, and eagles observed during aerial surveys in January and February 1985 in Sheridan County,Wy. Sample sizes are provided where more than 1 eagle was observed.



Adult Bald = ✲
Towns = ◊
Areas Surveyed =

Figure 10. Con't.



Adult Bald = ✲
Adult Bald, Immature = ☼
Golden = •
Immature = ✧
Towns = ◊
Areas Surveyed =

Appendix F. Maps of pronghorn winter ranges, major sheep ranches, and locations of eagles observed during aerial surveys.

Figure 1. Adult bald, immature bald, and golden eagles observed during aerial surveys relative to winter ranges of pronghorn and domestic sheep ranches with more than 2,000 sheep in Crook County, Wy. Sample sizes are provided where more than 1 eagle was observed.

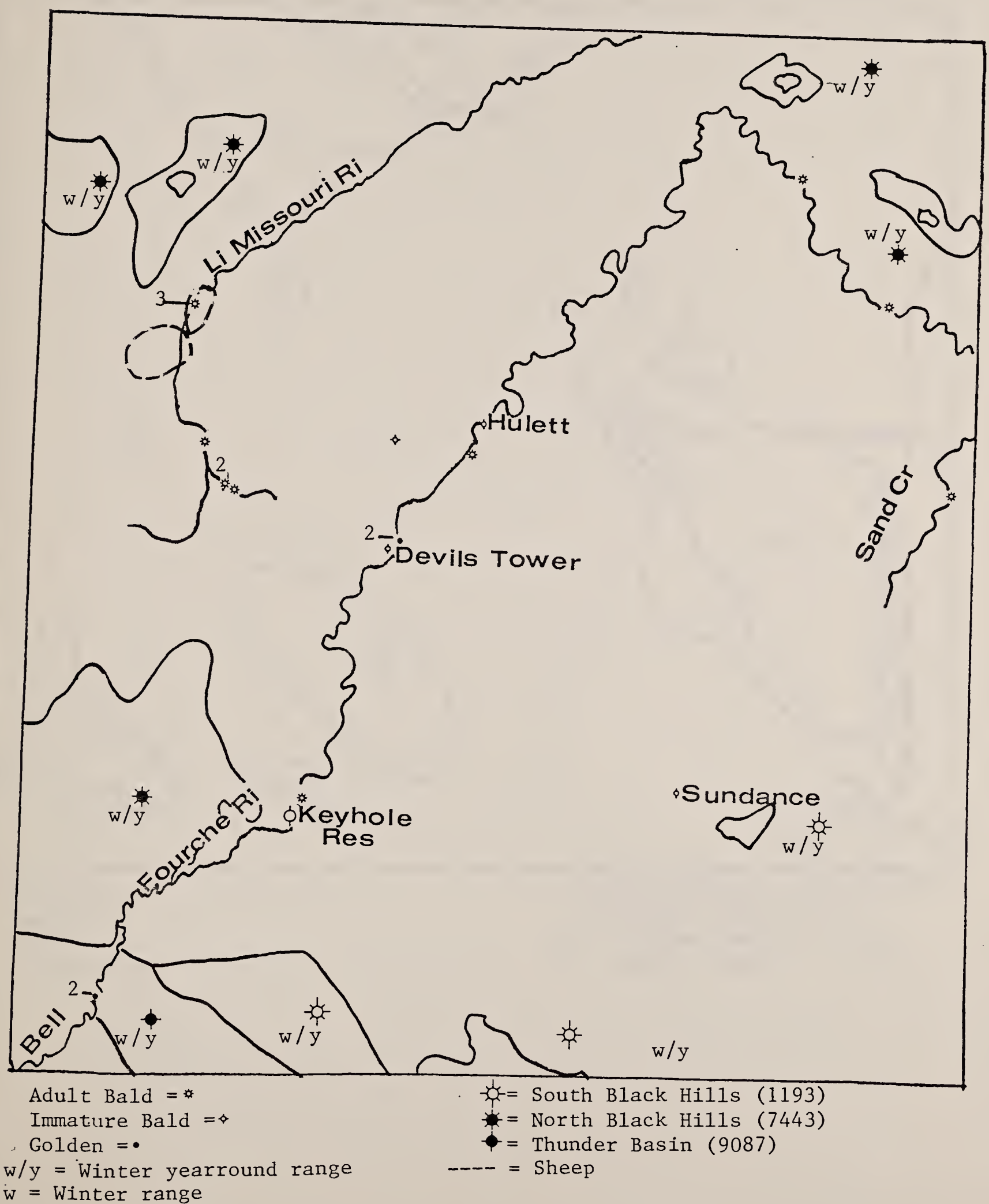
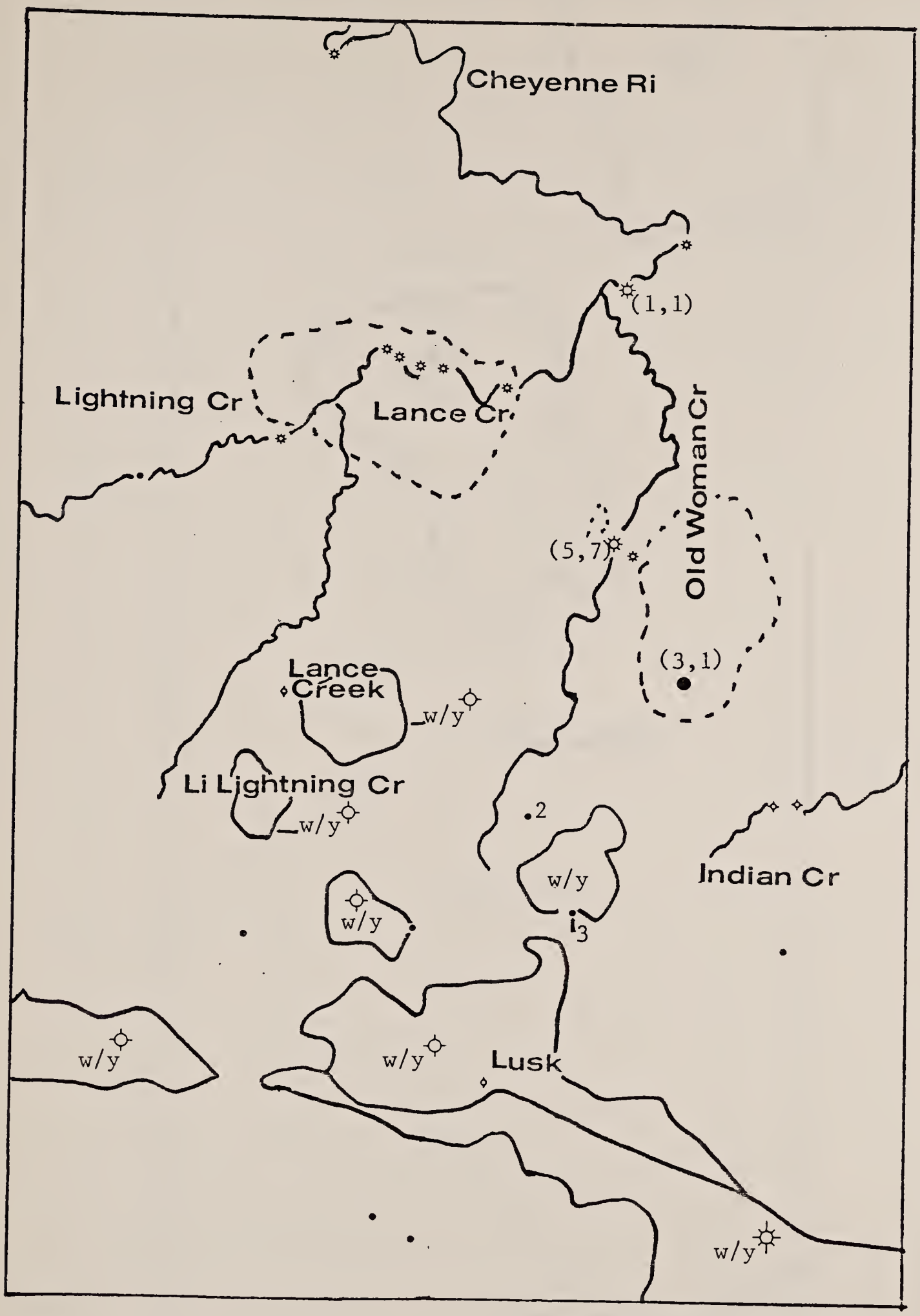


Figure 2. Adult bald, immature bald, and golden eagles observed during aerial surveys relative to winter ranges of pronghorn and domestic sheep ranches with more than 2,000 sheep in Weston County, Wy. Sample sizes are provided where more than 1 eagle was observed.

Adult Bald = ✲
Golden = •
Towns = ◊
Sheep = ----

✹ = South Black Hills (1193)
⌖ = Thunder Basin (9087)
w/y = Winter yearround range
w = Winter range

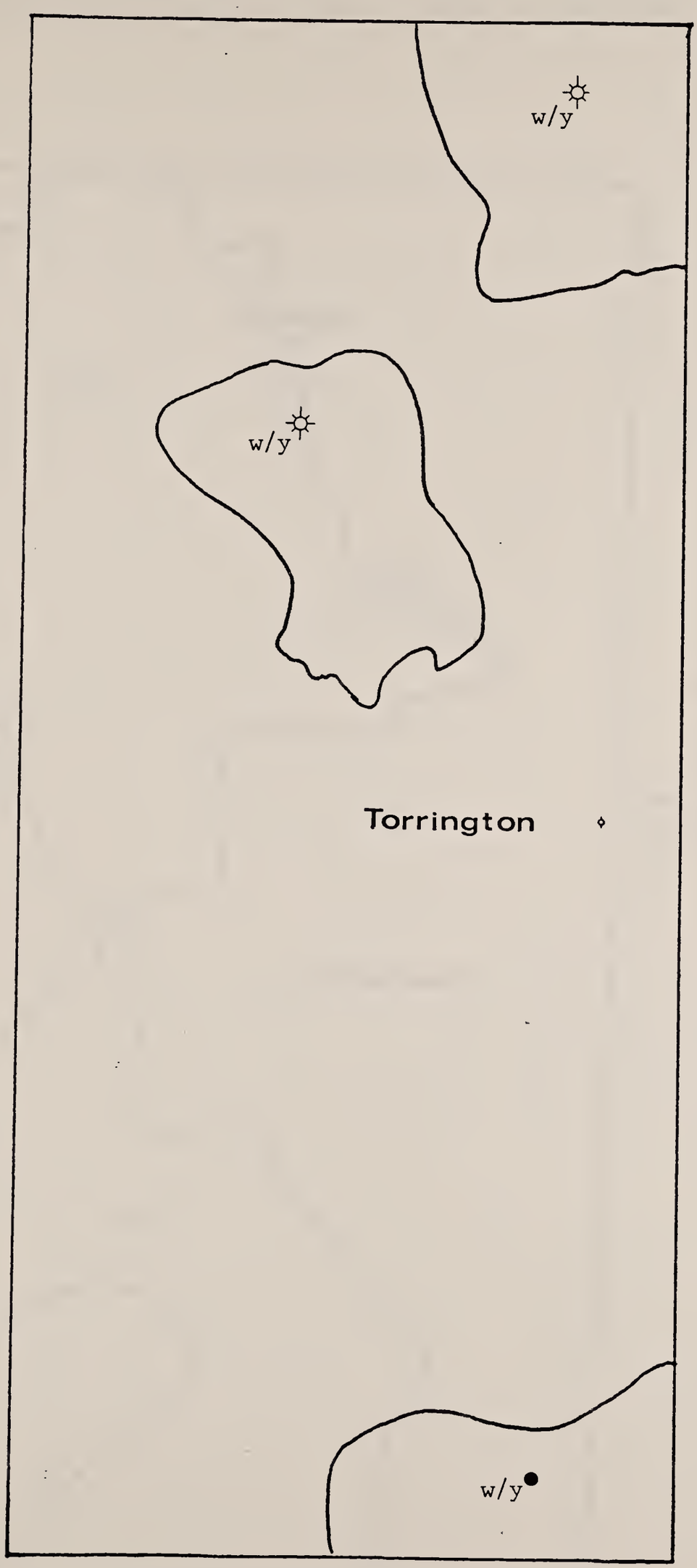
Figure 3. Adult bald, immature bald, and golden eagles observed during aerial surveys relative to winter ranges of pronghorn and domestic sheep ranches with more than 2,000 sheep in Niobrara County, Wy. Sample sizes are provided where more than 1 eagle was observed.



Adult Bald = ✲
Adult Bald, Golden = ●
Adult Bald, Immature = ☼
Golden = •
Immature Bald = ✧
Towns = ◊
Sheep = ----

⌖ = Lance Creek (2260)
☼ = Meadowdale (5337)
w/y = Winter yearround range

Figure 4. Adult bald, immature bald, and golden eagles observed during aerial surveys relative to winter ranges of pronghorn and domestic sheep in Goshen County, Wy. Sample sizes are provided where more than 1 eagle was observed.



Towns = ◊

● = Hawk Springs (4373)
☼ = Meadowdale (5337)
w/y = Winter yearround range

Figure 5. Adult bald, immature bald, and golden eagles observed during aerial surveys relative to winter ranges of pronghorn and domestic sheep ranches with more than 2,000 sheep in Platte County, Wy. Sample sizes are provided where more than 1 eagle was observed.

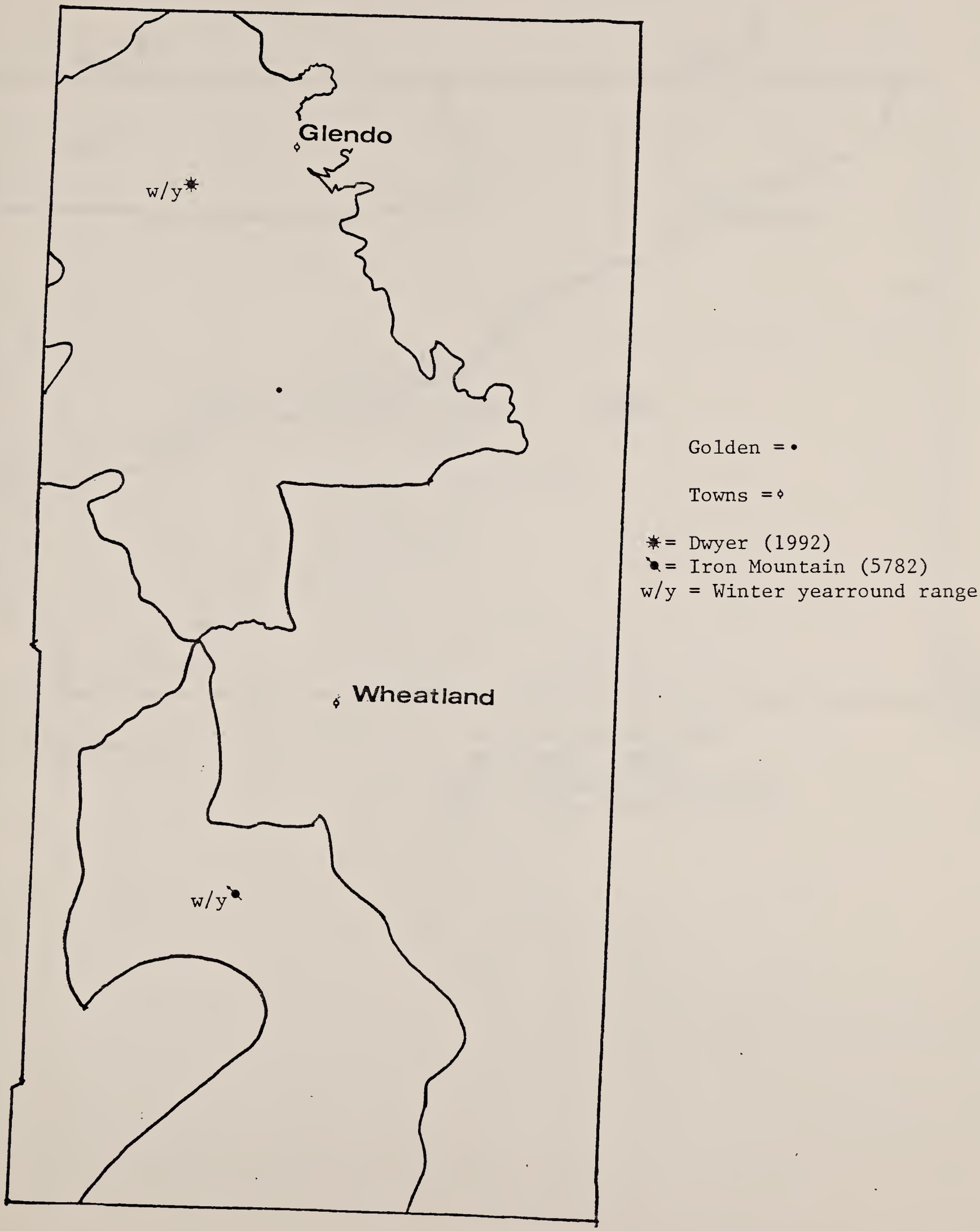
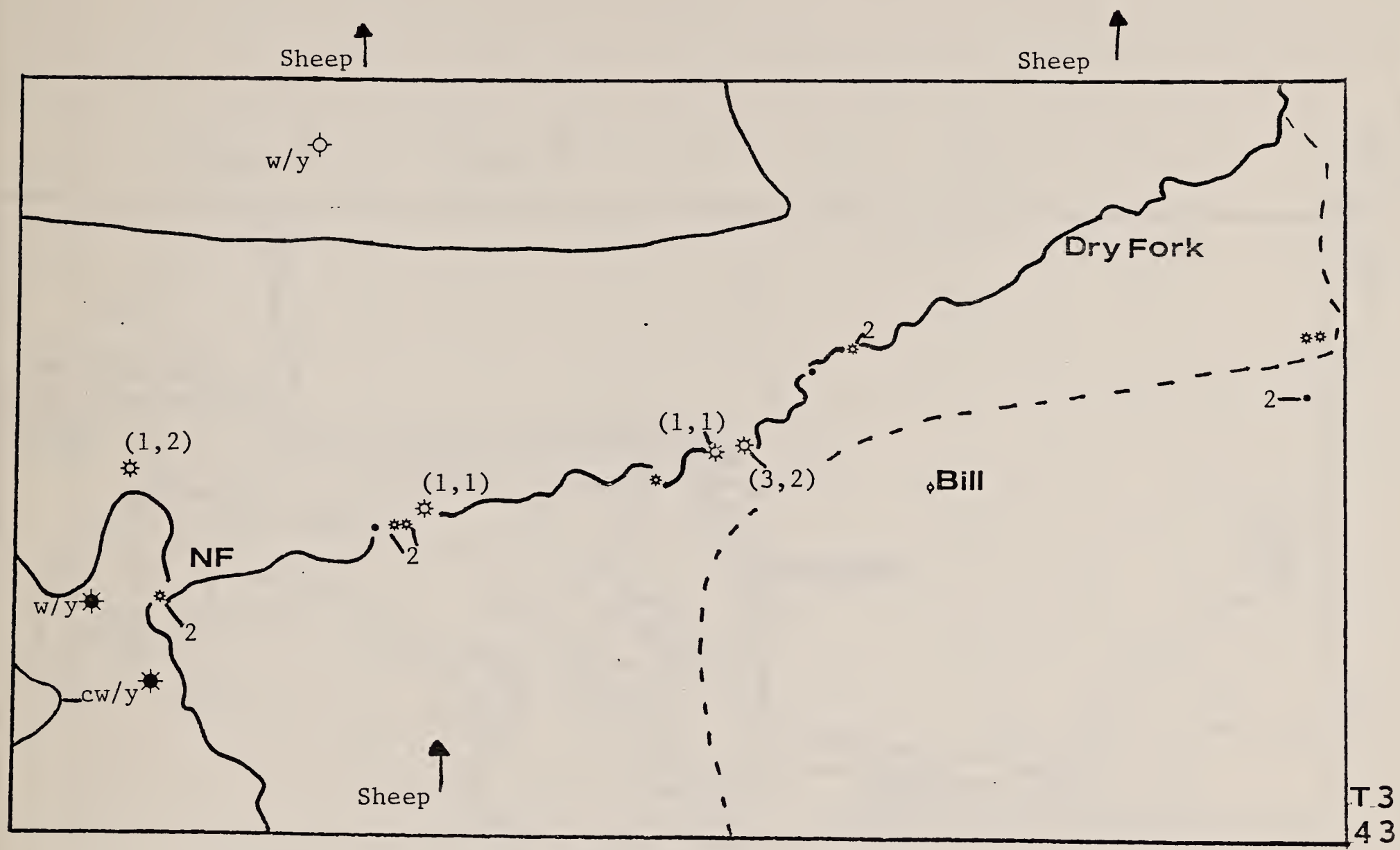


Figure 6. Adult bald, immature bald, and golden eagles observed during aerial surveys relative to winter ranges of pronghorn and domestic sheep ranches with more than 2,000 sheep in Converse County, Wy. Sample sizes are provided where more than 1 eagle was observed.



Adult Bald = ✲
Adult Bald, Immature = ☼
Golden = •
Towns = ◊
Sheep = ----

☼ = Bear Creek (1480)
✷ = Ormsby (3533)
cw/y = Critical Winter range
w/y = Winter yearound range

Figure 6. Con't.

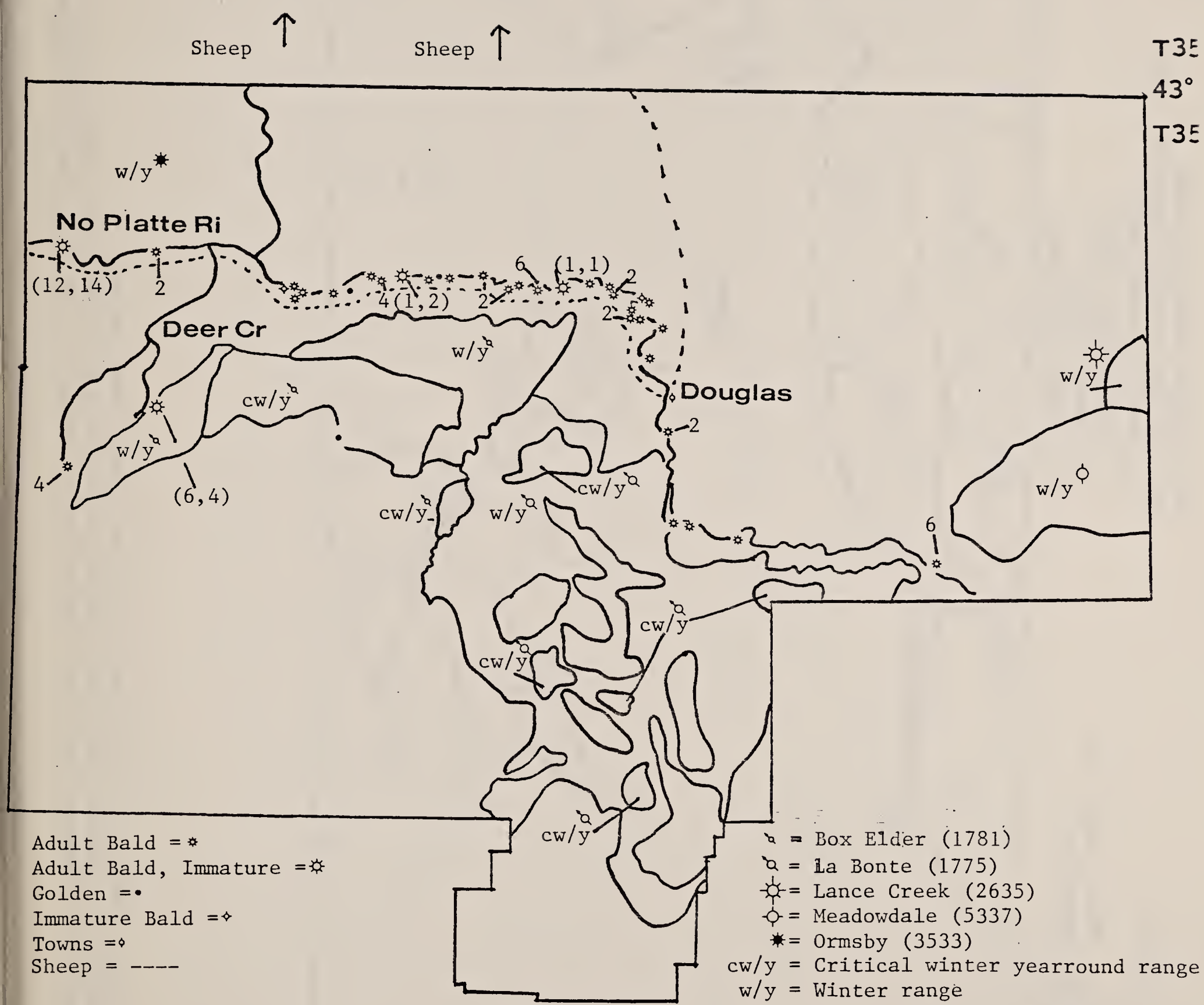


Figure 7. Adult bald, immature bald, and golden eagles observed during aerial surveys relative to winter ranges of pronghorn and domestic sheep ranches with more than 2,000 sheep in Natrona County, Wy. Sample sizes are provided where more than 1 eagle was observed.

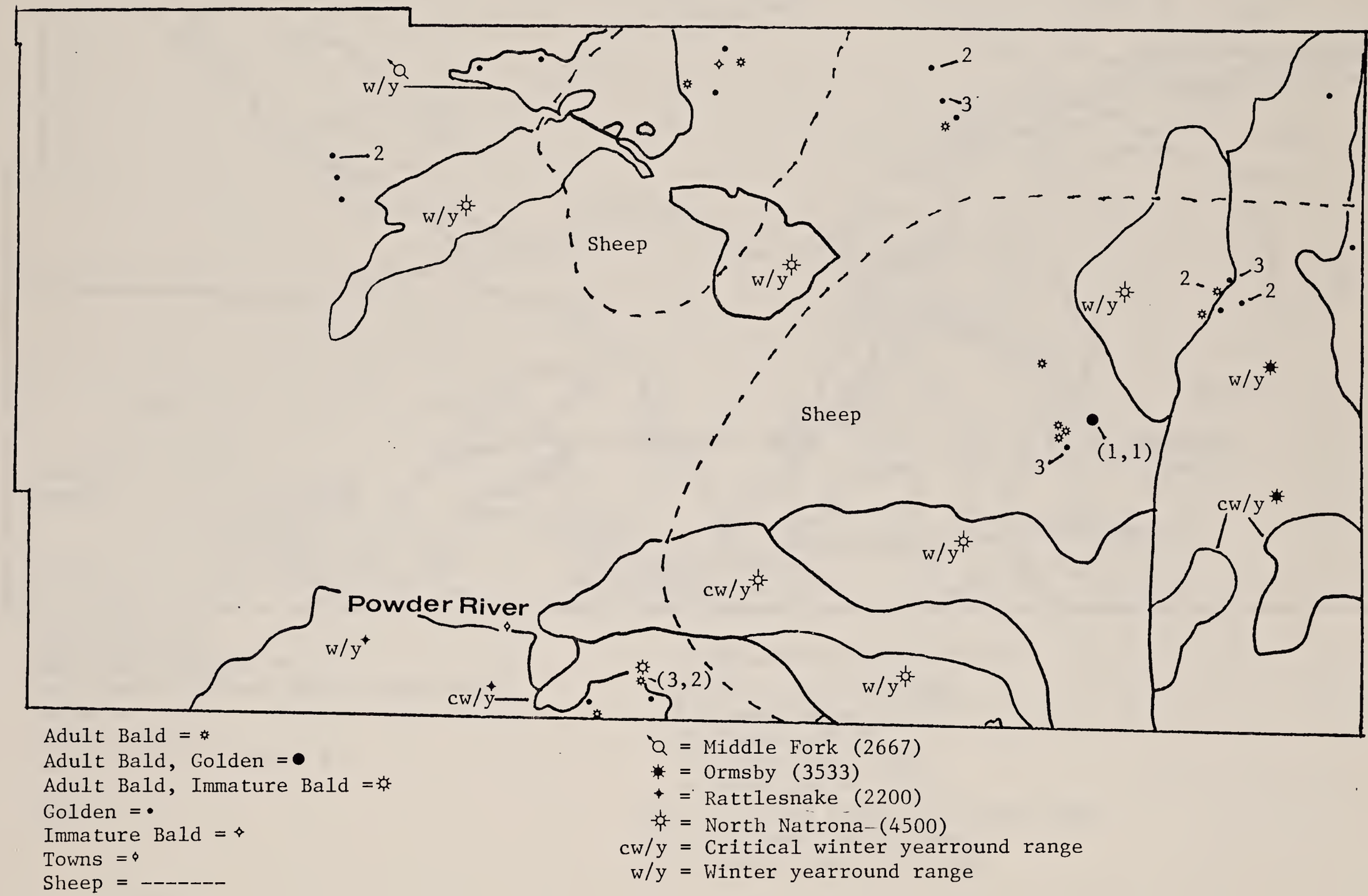


Figure 7. Con't.

Adult Bald =
Adult Bald, Golden =
Adult Bald, Immature Bald, Golden =
Golden =
Immature Bald =
Immature Bald, Golden =

Towns =
Sheep = ---------

= Bates Hole/Hat Six (5750)
= North Natrona (4500)
= North Ferris (7197)
= Ormsby (3533)
= Rattlesnake (2200)
= Sweet Water (6732)
cw/y = Critical Winter yearround range
cw = Critical winter range
w/y = Winter yearround range

Figure 8. Adult bald, immature bald, and golden eagles observed during aerial surveys relative to winter ranges of pronghorn and domestic sheep ranches with more than 2,000 sheep in Campbell County, Wy. Sample sizes are provided where more than 1 eagle was observed.

Adult Bald =✡
Golden =•
Immature Bald =✧
Towns =◊

☼= Gillette (8390)
●= Highlight (1190)
✷= North Black Hills (7443)
w/y = Winter yearround range

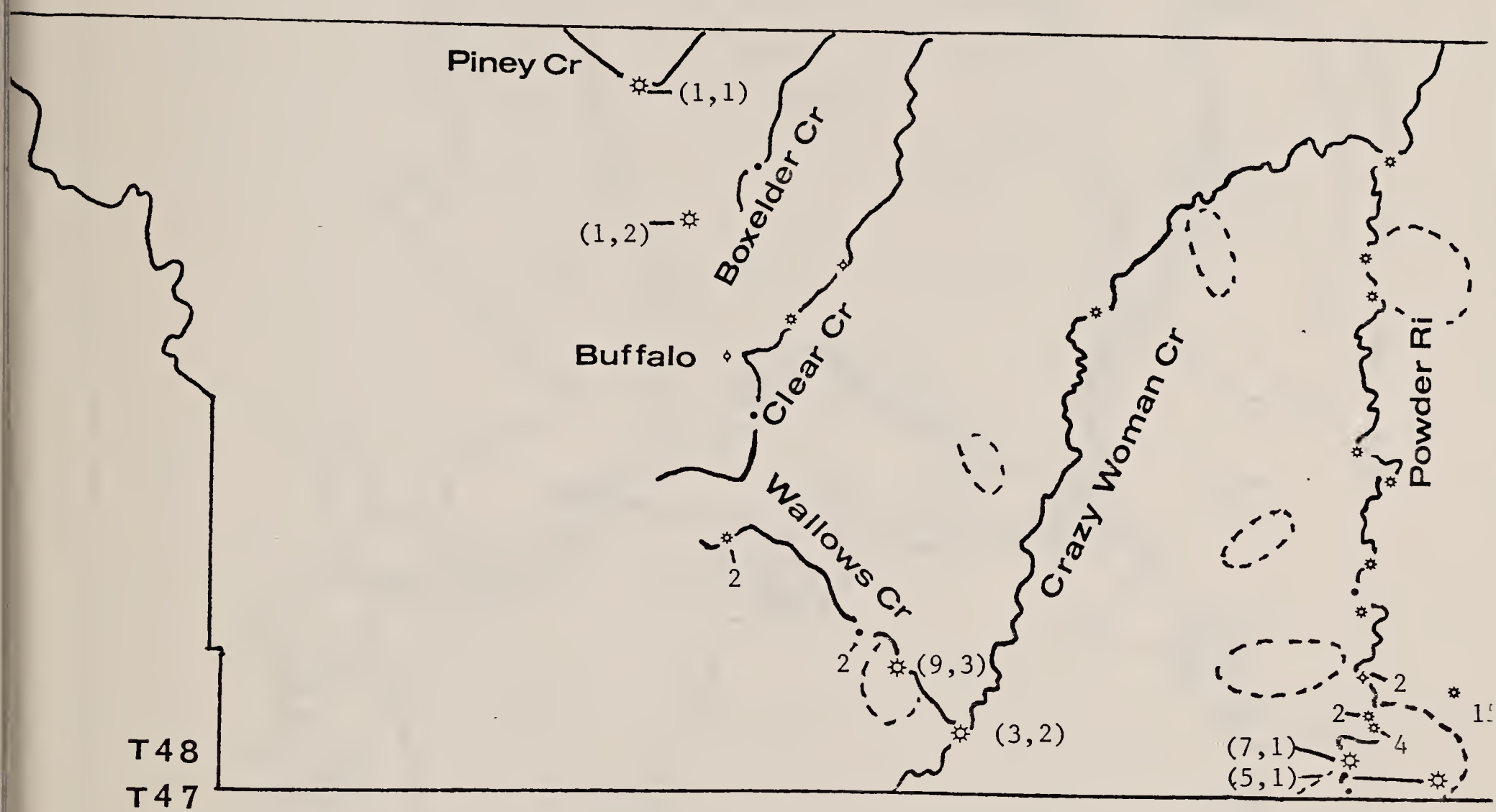
Figure 8. Con't.

Adult Bald = ✲
Adult Bald, Golden = ●
Adult Bald, Immature = ☼
Golden = •
Towns = ◊

Sheep = ----

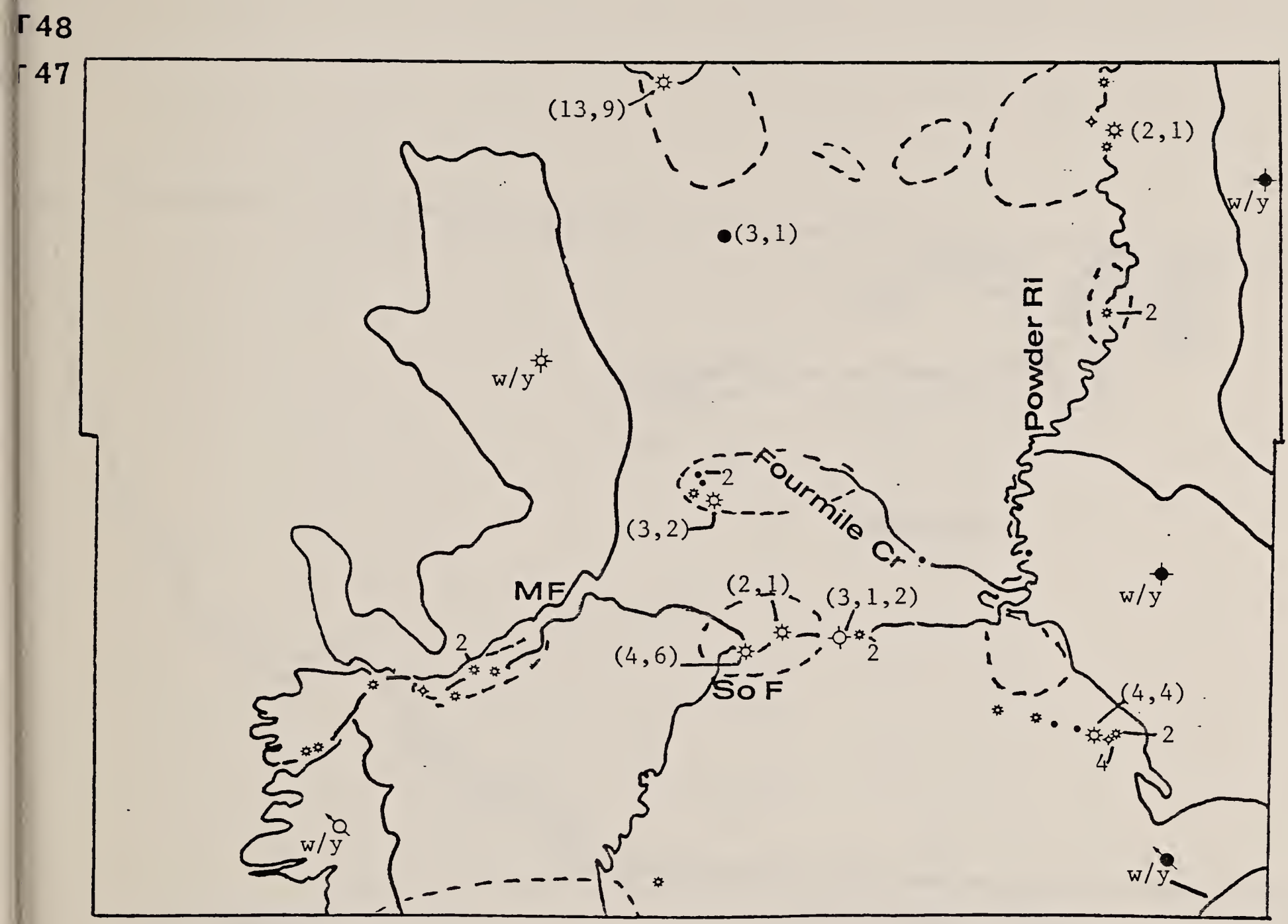
= Bear Creek (1480)
= Highlight (1190)
= Pumpkin Buttes (1319)
w/y = Winter yearround range

Figure 9. Adult bald, immature bald, and golden eagles observed during aerial surveys relative to winter ranges of pronghorn and domestic sheep in Johnson County, Wy. Sample sizes are provided where more than 1 eagle was observed.



Adult Bald = ✲
Adult Bald, Immature Bald = ☼
Golden = •
Immature Bald = ✧
Towns = ⬨
Sheep = -----

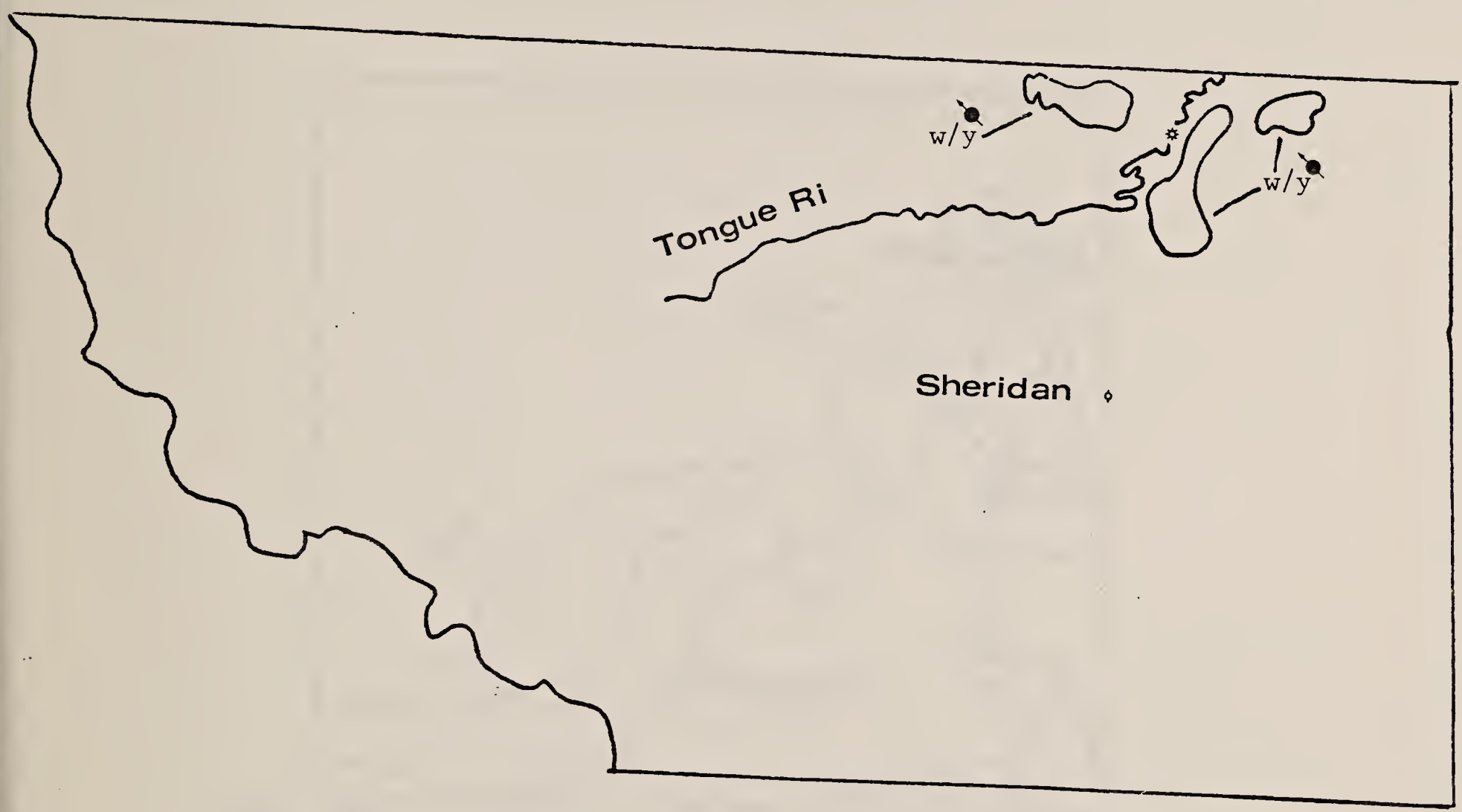
Figure 9. Con't.



Adult Bald = ✲
Adult Bald, Golden = ●
Adult Bald, Immature = ☼
Golden = •
Immature = ✧
Sheep = ----

= Bear Creek (1480)
= Middle Fork (2667)
= Pumpkin Buttes (1319)
= Upper Powder River (2320)
w/y = Winter yearround range

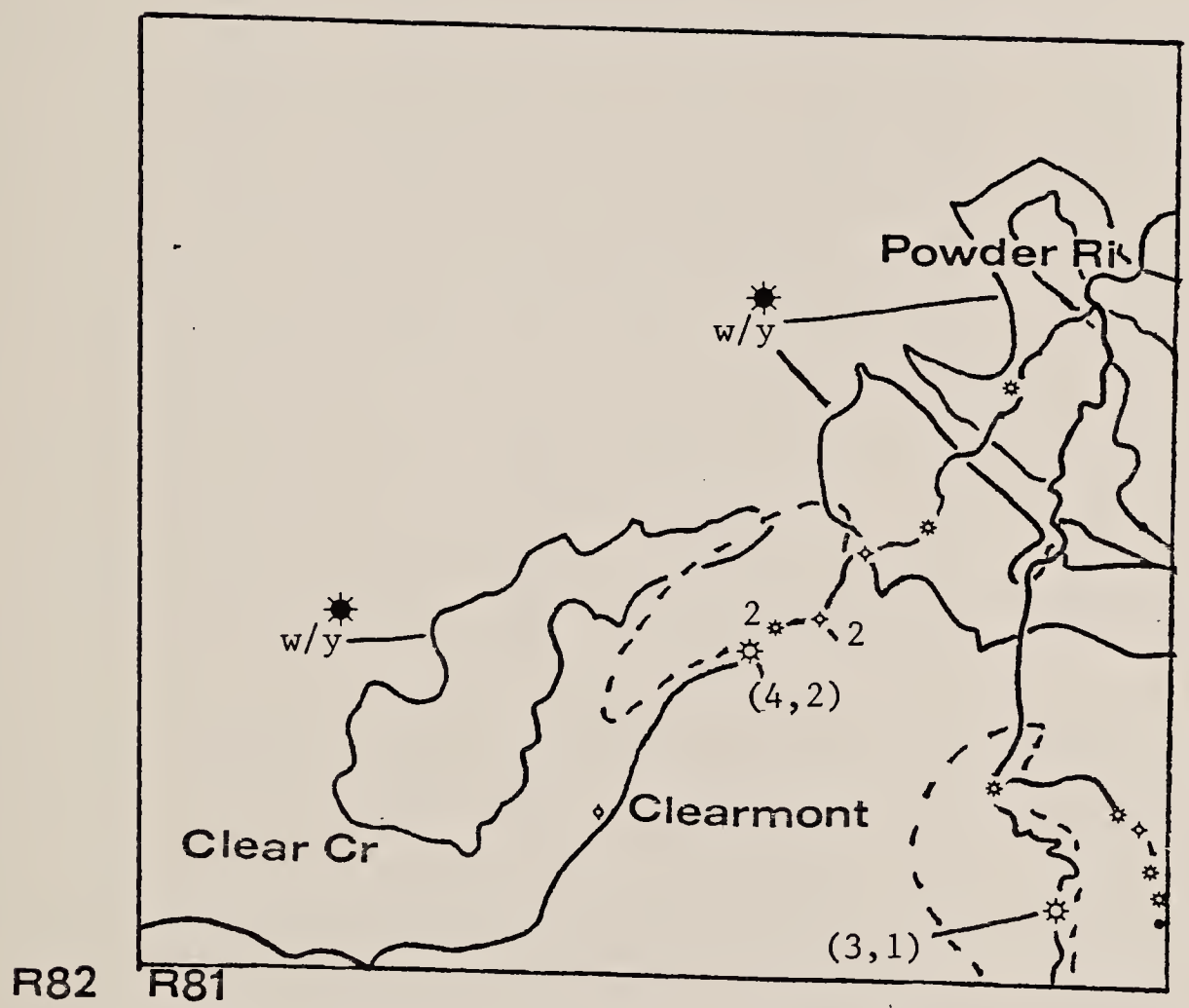
Figure 10. Adult bald, immature bald, and golden eagles observed during aerial surveys relative to winter ranges of pronghorn and domestic sheep ranches with more than 2,000 sheep in Sheridan County, Wy. Sample sizes are provided where more than 1 eagle was observed.



Adult Bald = ✲
Towns = ◊

● = Clearmont (2533)
w/y = Winter yearround range

Figure 10. Con't.



Adult Bald =✲
Adult Bald, Immature =☼
Golden =•
Immature =✧
Towns =◊
Sheep = -----

w/y = Winter yearround range
✷ = Gillette (8930)

Appendix G. Physiographic features of roosts in Northeastern Wyoming.

TABLE 1. PHYSIOGRAPHIC FEATURES OF ROOSTS IN UPLAND AREAS IN NORTHEASTERN WYOMING.

ROOST	LOS	DOV	HRS	HOR	SOR	SOO	AR	AO	OC	VW	DOV	DD	DO	DIR	DUR	DR	(MNEMONIC)*
ANTELOPE CREEK	100	75	48	48	50	50	22	202	135	112	45	3.2	0.6	1.3	0.6	1.6	
BAERTHEL CANYON (PINE MOUNTAIN)	999	500	72	42	20	50	22	247	315	315	45	1.4	3.4	3.5	0.6	20.0	
BOX ELDER CREEK	200	400	109	139	50	50	22	247	360	22	22	2.7	10.0	1.0	0.2	4.6	
BELLE FOURCHE	700	100	30	36	70	52	45	247	360	22	30	3.1	1.6	3.3	0.1	1.7	
BIG SULFUR SPRINGS WEST	480	190	36	42	50	40	45	270	180	22	22	4.8	10.0	4.1	0.2	20.0	
BIG SULFUR SPRINGS EAST	200	680	72	54	50	25	22	157	112	22	180	3.2	10.0	2.7	0.1	20.0	
CHEYENNE RIVER	100	200	36	24	50	50	360	202	90	90	22	8.2	1.6	7.8	0.6	12.2	
JACKSON CANYON	300	120	36	66	50	50	360	180	247	270	22	1.8	10.0	2.0	0.5	3.0	
KEYTON CREEK SOUTH	200	700	60	91	49	61	22	157	112	90	45	6.5	10.0	1.1	0.2	11.8	
KEYTON CREEK NORTH	500	320	103	109	55	46	67	225	135	79	67	5.5	10.0	2.0	0.6	12.8	
KEELINE A	90	100	18	24	40	50	45	270	157	157	45	3.1	3.3	3.9	0.1	4.6	
KEELINE B	120	180	42	42	50	50	135	292	225	180	90	2.8	3.5	3.2	0.2	3.2	
KEELINE C	300	100	30	30	40	40	45	247	315	315	67	3.5	1.2	3.8	0.3	5.1	
KEELINE D	100	400	60	60	40	30	45	247	360	67	45	2.8	1.1	2.9	0.2	5.0	
LITTLE DEER CREEK EAST	300	140	36	60	50	40	22	270	292	22	22	4.1	1.7	2.7	0.7	2.4	
LITTLE RED CREEK	400	200	72	152	50	50	22	225	315	337	45	6.3	10.0	5.0	0.1	9.5	
MILLER HILLS A	200	150	24	36	20	40	45	292	135	90	45	6.4	10.0	4.6	0.1	3.5	

TABLE 1. CONT.

MILLER HILLS B	200	170	30	30	40	40	45	225	135	135	45	6.3	10.0	3.2	0.1	3.1
SOUTHWEST CANYON (PINE MOUNTAIN)	500	300	54	30	25	30	337	157	225	225	45	6.2	0.6	2.0	0.2	20.0
WEST CANYON (PINE MOUNTAIN)	220	240	30	54	50	30	22	247	315	337	45	6.9	1.5	1.5	0.6	20.0
WEST RIDGE SOUTH (PINE MOUNTAIN)	999	70	66	42	21	73	22	247	315	303	90	1.3	3.2	3.1	0.4	10.0
SCHOOL CREEK	180	120	48	48	30	40	67	292	360	360	45	5.1	3.1	0.0	0.2	2.2
SEAMAN HILLS	200	150	42	42	50	50	45	157	112	90	67	4.0	10.0	4.0	0.4	8.0

*

LOS - LENGTH OF ROOST SLOPE (M)
HRS - HEIGHT OF ROOST SLOPE (M)
SOR - SLOPE OF ROOST (%)
AR - ASPECT OF ROOST (DEG)
OC - ORIENTATION OF CANYON (DEG)
DOV - DEGREES OF VIEW FROM ROOST SLOPE
DO - DISTANNCE TO NEAREST OIL DEVELOPMENT (KM)
DUR - DISTANCE TO UNIMPROVED ROAD (KM)

DOV - DISTANCE ACCROSS VALLEY AT WIDEST POINT (M)
HOR - HEIGHT OF OPPOSITE ROOST SLOPE (M)
SOO - SLOPE OF VALLEY OPPOSITE ROOST (%)
AO - ASPECT OF SLOPE OPPOSITE ROOST (DEG)
VW - AVERAGE DIRECTION OF VIEW FROM MIDPOINT OF ROOST SLOPE (DEG)
DD - DISTANCE TO NEAREST OCCUPPIED DWELLING (KM)
DIR - DISTANCE TO IMPROVED ROAD (KM)
DR - DISTANCE TO RIPARIAN AREAS WITH COTTONWOODS (KM)